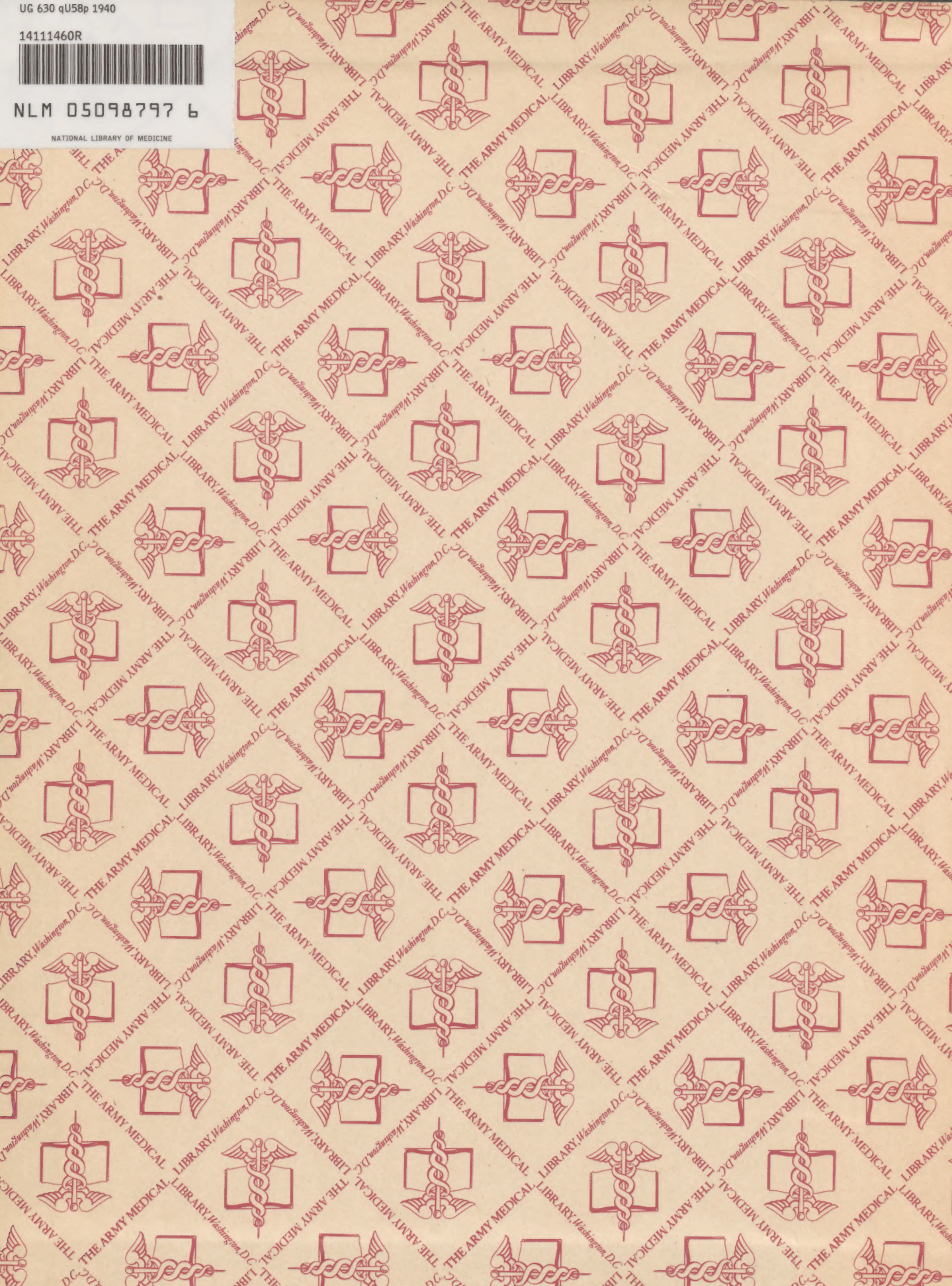

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ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE ARCTIC (THREE LECTURES)

A-I. LECTURE I—GENERAL CONDITIONS

[1944?]

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ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
ARMY AIR FORCES
* * *
School Lectures

THE ARCTIC

Lecture I:
General Conditions

I. INTRODUCTION

Of the three extreme areas to be discussed in this series of lectures, probably the most healthful for adequately equipped soldiers is the Far North. There is least danger of infection in normal operations, either from food, or wounds, or water, although of course wounds require quick attention in the cold. There is probably less likelihood of neurosis and mental breakdown among ground crews from life in the arctic than there is from military duty in tropical or desert regions. Life in the arctic is not easy, for two obvious reasons: the rigors of climate and the difficulty of moving supplies. But intelligent, well-trained soldiers can maintain a high level of personal and military efficiency, once they have mastered a fairly limited body of knowledge.

A. Adjustment Requires Preparation

One general suggestion about duty in strange areas of the earth applies here: people have lived there for a long time, have mastered their surroundings, and would not want to live anyplace else. This does not mean that you have to think of settling down for good where you are assigned; but it does mean that you can adjust quite successfully to the area, if you make certain preparations--of clothing, food, health habits, and mental attitudes.

You can learn a certain amount by giving these lectures a fair hearing. Of course you cannot assimilate everything said here. But you can get an idea of the outlines of the subject, and learn more by getting more material and even by hearing the lectures over again. Learning never stops. Even if you think you know it all, you have to keep reviewing what you know, so you will not forget. And then, most important: practice what you have learned, so it becomes habit. Habit is the basis of any training, especially military. Surely you should train yourselves in habits that may save your life.

B. What the Arctic Is Not

Before outlining the general characteristics of the arctic regions, it is necessary to clear up what the arctic is not. Please

do not consider that your intelligence is being insulted if you hear what you already know. In the Army we can take no chances.

1. "Dead Ice". What ideas might some soldiers have about the arctic that are not so? One general notion, not so widespread as it used to be, is that the polar regions are one solid mass of deep ice, supporting no life. Well, the only substantial area of solid, permanent northern ice is in Greenland. The North Pole is covered by the sea, of which the ice is continually moving, and cracking, and drifting. The Soviet expedition which set itself adrift right near the pole saw plenty of animal life in water and on the ice.

2. "Terrific Cold". A second idea is that the Far North is an area of terrific, unrelenting cold. It is time here to point out a general principle. Water serves as a conservative or stabilizing agent, holding heat. Thus, temperatures on or near the water undergo much less variation than they do inland. For instance, the coldest spot in Siberia is about 200 miles south of the Arctic Circle, and far inland. The sea itself, and the coasts of Alaska, and the Aleutian Islands, are warmer in winter than the inland areas, and cooler in summer.

3. "Dismal Dark". "The winter is a period of unrelieved darkness, when the sun goes away and you think it will never come back"--that is what many think. It is true that you do not see the sun for a time, and that there is danger of mental depression. But there is plenty of light from reflection, especially on moonlit nights; and vigorous, active soldiers can cook up ways to keep cheerful and occupied. They will not be snowed in; they will be busy.

4. "Remember the Summer". Do not forget northern summers. Continual sunlight causes an accumulation of warmth during the short summer season, bringing a quick upsurge of vegetation--and insects. Even if the ground is frozen one or two feet--or inches--below the surface, there is enough soft soil to support plant life. Much of this plant life remains under the snow available for food through the winter, for both animals and men. So remember there is plenty of life around--animals and plants on land, animals and fish and plants in the sea, both summer and winter.

II. THE ARCTIC DEFINED

"Arktos", the Greek word bear, the Big Dipper, and the North, or Pole Star, combine to name the northern regions of the earth. The Great Bear is another name for the Dipper, with its conformation always aiming at the Pole Star. The "Arctic" is the region under the Great Bear (Ursa Major in Latin).

A. Arctic

The arctic can be defined mathematically, although this is no clear guide to living conditions. The common definition is that it

is bounded by the Arctic Circle at 66° 33' North Latitude. However, it is more accurately delimited on a temperature basis. It is the region within which the mean temperature for the warmest month is less than 50° F.

Another practical way of determining arctic regions is to consider that area north of timber line as arctic. But along certain Siberian rivers forests grow to even 400 miles north of the Arctic Circle; in Alaska and on the Canadian Mackenzie River, almost 125 miles north of the circle. But along the west shore of Hudson Bay, the treeline is 400 miles south of the Circle. The determining factor in tree growth is not distance from the pole, or nearness to warm ocean currents, but summer temperature. Distance or protection from summer sea winds permits warmth in summer, and growth of trees.

B. Sub-Arctic

The Sub-Arctic is a belt of variable width south of the Arctic Region. Within it the mean temperature of the warmest summer month is higher than 50° F. It includes islands which, because of coolness in summer, do not grow trees, but which do not reach temperatures as low as the lowest in Kansas or Pennsylvania. It is agreed to include most of the mainland of America and Eurasia which drains northward into the Polar Sea or into other waters which have ice in winter. In Canada, the Yukon and the Northwest Territories are called sub-arctic, and the land north of Lake Winnipeg in Manitoba and north of the divide in Ontario and Quebec. All of Labrador, and all of Alaska, except perhaps the panhandle and southern coast, can be considered sub-Arctic. In Siberia, most of the area north of the Trans-Siberian Railway, and in Europe, Norwegian, Finnish, and Swedish Lapland, and Russia north of Leningrad are called sub-arctic. The terms must be used flexibly, and we certainly should not be frightened by them.

III. GENERAL FEATURES OF THE LANDS

Within limits, certain general statements can be made about the entire northern area. Factors of topography, drainage, ground frost, and ice development can be broadly summarized.

A. Topography

The arctic and sub-arctic lands are generally low. The rivers are not very deep, but are navigable some distance from the mouth by flat-draft boats. Exceptions to the general flatness are the Aleutians, Greenland, Iceland, Alaska, and the Yukon.

The Aleutian Islands are largely mountainous, with some active volcanoes. The pictures we saw of action on Attu give a fair idea of the difficult terrain. Rain and snow are heavy, but the islands are not large enough to develop rivers of any size. The mountains are not high enough to preserve snow, so there are no glaciers.

The south coast of Alaska has magnificent scenery, with fjords running between mountains close to shore. Mount McKinley is North America's highest peak (20,300 ft.). Other high mountains in the region are especially imposing because they stand on lowland near the water.

Alaska, mountainous over almost its entire area, is drained by the Yukon, the peninsula's largest river, and the Kuskokwim. The Alaskan mountains are an extension of the high Yukon structures, which extend east into part of the Canadian Northwest Territories. The great Mackenzie River, second to the Mississippi in North America, drains the Northwest Territories and the eastern part of the Yukon highland.

Greenland has mountain ranges running north and south along the east and west coasts; but next to nothing is known about the land of the interior because it is submerged by a great ice cap which covers more than 80% of the whole island. The highest mountains of Greenland are near the east coast, a few going above 10,000 feet, while the mountains on the west coast average about 2000 or 3000 feet lower.

Iceland's mountains, which are not much higher than 5000 feet, rise sharply from the ocean, giving an impression of ruggedness and grandeur. The water around Iceland is so warm that there is much precipitation, forming inland glaciers which melt too soon to reach the sea.

B. Water and Drainage, and Frosted Ground

Several interesting problems in geography are closely related. What effect have rain and snow on the soil? What effect have mountains on precipitation? What relation is there between amount of precipitation, and freezing of the ground? What effect have glaciers on ground-frost, and what causes glaciers? Finding the answer to one of these problems helps round up the answers to all.

1. Rain and Snow. Throughout both arctic and sub-arctic, precipitation is heaviest in summer. Sections away from the coast have very little precipitation from December to March. The Aleutians, of course, being surrounded by water which is never frozen, have much snow, rain, and fog all year round. The annual precipitation is more than 60 inches. The snow melts in the summer, forming swift streams from the mountains. But what of the lowlands, especially those farther from the sea? Where do the rain and snow go, no matter how slight? The moisture cannot sink far into the ground, because the ground is frozen, even in summer. In many places the frost comes within an inch or two of the surface. Even where the summers are warm enough to grow trees and wheat, the ground in a forest may be frozen a couple of inches below the surface; trees have to send out successive strata of roots as new soil and muck gather, causing the layer below, in which the tree first took root, to freeze. As a result of this inability to sink, water either

causes swollen streams, or else gathers into innumerable lakes. Where the terrain is flat, the shallow lakes may cover as much as 60% of the ground surface. The bottom of these lakes is usually soft mud, for a couple of inches, and then, the hard frost. In the mountains this lake-forming effect of ground frost is not conspicuous.

The Yukon and Mackenzie ranges cut off a great deal of the moisture in the Pacific Ocean winds; this is one reason why half of Canada has permanently frozen sub-soil. Areas with plentiful and regular rain and snow are likely to have a more even climate, with less temperature variation between seasons. Frozen soil is caused by a combination of extremely cold winters (occurring in the inland regions) and a thin blanket of snow.

2. Frost and Glaciers. Contrary to the old theory that ground freezes under glaciers, and that frozen ground is a relic of the old glacial period, when ice is supposed to have covered the earth down to about Kansas City, it is now believed that land underneath a glacier is seldom if ever permanently frozen. In the heavily glaciated region of southern Alaska there is very little permanently frozen ground, and underground drainage functions normally.

3. Areas of Frost. Groundfrost begins approximately on lines going northwest and northeast of Lake Superior; northwest to the southern Yukon, northeast to mid-Quebec and Labrador. Islands of permanent frost become more numerous as one goes northward, until they meet in a vast underground sheet. In Greenland, the northern area has frozen sub-soil, except those parts emerging from beneath a retreating glacier. No permanent ground frost has ever been found in Iceland: winters are not cold, and the blanketing snowfall is heavy.

Near the southern limit of permanent frost, the ground will thaw down to about 7-9 feet by the end of summer. As one proceeds north, this depth decreases. In forest regions keeping out the sun, the ground will thaw hardly at all. North of the forest, where the sea wind prevents the growth of spruce but not the growth of sedges, grasses and bushes, summer thaw is deeper, maybe as much as a foot, and even deeper in sandy soil. Still farther north, and in the Canadian islands, the thaw again grows slight.

C. Lakes and Rivers

About 30% of the Northwest Territories is covered with water; in some sections, as between the Mackenzie and the Anderson Rivers, the figure is 60%. Two lakes in this territory, the Great Bear and the Great Slave, are fourth and fifth in size in North America; the first three are Superior, Michigan and Huron.

The sub-arctic around Hudson Bay is drained by a large number of small rivers, which are shallow and full of rapids and falls.

The Mackenzie itself is navigable for about 1300 miles, for boats drawing six feet north of a set of rapids, and four feet south of them ("north" means "below" in arctic and sub-arctic rivers). The Mackenzie valley, in several respects much like the Mississippi, is much more uniformly forested, and the level land is thickly dotted with lakes.

D. Glaciers

There are two major kinds of glaciers--ice caps such as the great mass of ice which covers most of Greenland, and valley glaciers. The picture of the latter type is the more common: a band of white filling a valley with ice and snow, slowly melting and moving toward lower levels--usually the sea. Icebergs result from glacier ice which breaks off and floats down to the sea. The glacier-bearing areas of the western hemisphere are found in the eastern and northern tier of islands north of Canada--Heiberg, Ellesmere, Devon, the rough eastern coast of Baffin; and greatest of all--Greenland. From the east coast of Greenland come most of the icebergs which roam down to the north Atlantic, sometimes as far south as the Newfoundland Banks. Although most glaciers move on the order of inches in a week, there have been records of 125 feet in 24 hours by certain Greenland glaciers, near the sea.

Southern Alaska, where the mountains are close to the sea, has a great many glaciers, but elsewhere on the Alaskan coast there are few. The Aleutians, which do not collect ice, have no glaciers. On the mainland of Canada there are no glaciers east of the Rocky Mountains.

IV. THE ARCTIC SEAS AND SEA ICE

You have to look at a globe to get a good picture of the so-called Arctic Ocean. Probably the first fact to strike you is how small it is, compared to the other oceans of the world. Stefansson, the famous explorer and writer on the arctic, uses the term Arctic Mediterranean Sea as more fitting a body of water that can be flown across with no diameter exceeding 2000 miles. The importance of the polar routes for air travel from America to Europe or Asia is made apparent by such figures.

A. Ice on the Polar Sea

Do not think of the polar sea as a solid mass of ice, even in winter. Substantially all the ice in the northern sea moves around in a slow, clockwise eddy, with smaller eddies here and there on the margin. Not even near the "ice center", and not even in February or March, the coldest months, are there any very large individual stretches of ice. This "ice pole" is also called the Ice Center and the Pole of Inaccessibility, being the center of the region of ice which cannot be entered by ships under their own power. Because of the movement of the ice, there are always leads and lanes of water. It is rare that you travel more than twenty or thirty miles before coming to a crack, which may be anything

from a few inches to a few miles in width. This crack may be open water, or may have an ice film from some inches to some feet in depth, depending on the recency of the opening.

Some open water is caused by the grinding of floe on floe, with the heaping up of one floe on another, forming a pressure ridge. Leads that open in winter in this and other ways are quickly cemented by the frost, producing areas of level ice favorable to the sledge traveler, and, of increasing importance, to aviators for landings and takeoffs.

B. The Gulf Stream and the Pack Ice

The ice-covered area is not uniform around the pole, but is lop-sided. The Gulf Stream, that amazing body of sun-warmed water that flows north and east from the Gulf of Mexico, still has enough calories in it after passing between Iceland and Norway to prevent ice from forming there, and thus it in effect pushes the pack ice toward the Alaskan side of the arctic basin. The center of the ice-covered area is about 400 miles to the Alaska side of the North Pole.

In winter the ice of the northern sea comes flush up against most of the northern coasts--Greenland, Canada, Alaska, Siberia. But from Norwegian soil no one has ever seen drifting salt water ice, because the pack is always kept back by the comparatively warm water. And at Iceland, coastwise mail steamers seldom have difficulty in circumnavigating the island at any time.

C. The "Passages"

Most of the channels between the Canadian islands open up in summer every year, except those between the second tier of islands, north of Melville Island. By June, decreased chill in the air and increased blankets of snow combine to prevent the formation of new ice, even at the ice pole. The southern edges of the ice cap disintegrate and recede, the famous waterways or "Passages", called Northeast and Northwest with respect to England, open up. With improved airplane scouting and weather reporting by radio, as demonstrated by Soviet navigators in recent years, those passages may enter a period of increased usefulness.

In September and early October the freezing is hampered by blankets of soft snow. But snowfall decreases, and during the period from December to March there are no fogs and few clouds over the main body of the ice pack. Freezing goes on so speedily that in three days sledge travelers can pass over what was open water; airplanes can land in another three days.

D. Pressure Ridges

But movement of the pack ice goes on all the time. Although ordinarily ice would get to be only about seven feet thick in a

winter of ordinary freezing, the grinding and heaping movement may cause thicknesses of 100 feet, as one floe slides under another. Such parts of the floe are comparatively stable, although in constant sluggish motion; you can set up residence on them through the winter with almost the solidity of a residence on land. The Russian expedition headed by Papanin spent nine months, from May, 1937, to February, 1938, on the ice, fully equipped with scientific instruments.

The blocks and piles of ice are called pressure ridges. They are angular upon formation. But it rains at the North Pole, as well as at every other point in the Arctic Mediterranean, and this rain, with mid-summer sun, thaws the ice and snow. By the second year the blocks of ice have been toned down and rounded; by the fourth year, all appearance of the block structure has been lost, and the ice looks like a rolling prairie, with hummocks seldom more than 15 or 20 feet high.

E. The Ice Drifts

We know that the ice moves, and we can also plot roughly the currents which move it, as a result of the paths covered by ships, occupied or abandoned, drifting along with the ice which beset them. We also have the routes plotted by men who camped upon moving floes. Stefansson believes that there is a basic clockwise current around the ice pole, with a number of minor eddies on the outskirts of the main drift, especially off the Siberian coast. An ice floe at the North Pole, such as the one on which the Papanin expedition was landed by plane, would gradually drift to the North Atlantic, in the vicinity of Iceland. The North Pole is itself a way-station on the migration of ice, and not the center.

1. The Main Drift. If you choose an ice floe which is fairly close to shore, it will start on a long journey all around the Arctic Mediterranean before it finds itself over the North Atlantic. Let us pick a piece of ice off Point Barrow, North Alaska. In successive years it will be west of Wrangel Island north of Siberia; farther west the next year, north of Franz Joseph Land; the next, it drifts westward and southward, past Spitsbergen, into the gap between Norway and Greenland.

This plan of the drift is supported by the experiences of several iced-in ships. The Karluk of the third Stefansson expedition was beset about 25 miles north of Alaska and drifted westward until she was crushed, less than four months later, 50 miles northeast of Wrangel Island, which is near the northeastern tip of Siberia. De Long's Jeannette started to drift in 1879 near the same Wrangel Island, went in the same western direction along the coast, and was crushed a year and a half later north of the New Siberian Islands. Nansen's and Sverdrup's Fram was beset near these islands in 1893, and after almost three years of drifting, passed the top of Europe and came free of the ice near Spitsbergen.

2. The Eddies. But that there are great eddies to complicate this drift is proved by the paths of three ships, the Navarch, the Baychimo, and the Maud, which kept reappearing in the same regions in which they had been beset. One such eddy is north of Point Barrow, Alaska, and several others north of Asia.

After getting past Spitsbergen on the way south, the ice will melt within a few weeks if it passes east of Iceland--that is, into the Gulf current. But if it passes west of Iceland, south along the eastern coast of Greenland, and then maybe west around the southern tip of Greenland, then south again, it may last about six months more.

This discussion of the drift of the polar ice will help dispel any notion of a solid, still expanse, devoid of life and movement. There is much change going on, and, as we shall see later, much animal and plant life made possible by the movement.

F. Icebergs

The berg that sank the Titanic probably came from western Greenland, or the east coasts of the Canadian Islands, Ellesmere, Devon, and Baffin. There are no icebergs in the Arctic Mediterranean. The difference between an iceberg and an ice floe is that bergs come from formations of land ice, forced down to the coast and into the sea. Some few small bergs come from the edges of the Arctic Mediterranean, from Northern Land, the Franz Joseph Islands, and Spitsbergen or Svalbard. These start moving west and south immediately.

G. Arctic Tides

In the Arctic Mediterranean, lunar tides are negligible. Regular tides of two or three feet are considered high anywhere in the arctic. But there are also "storm" tides, preceding a strong wind. On the north coast of Alaska, for example, east of Barrow, a rise of as much as 5 or 6 feet may precede a westerly gale, giving warning of its approach about 8 or 12 hours beforehand. These storm tides go up the Mackenzie River as much as 200 miles; they are also felt in other rivers of America and Siberia which empty north. But the strongest tides, of 6 feet, may not occur more than once in three years. A "low tide" may be caused by an easterly wind. This drop in water level is usually less pronounced than the westerly wind's lift.

The low arctic lunar tides, like those of the Mediterranean between Europe and Africa, result from the enclosure of the sea between land masses. The two seas are effectively cut off from the great world ocean. But in the main bodies of the Atlantic and Pacific, the sub-arctic may have tremendous tides--33 feet in South Alaska, 55 feet in Frobisher Bay, Baffin Island.

V. CLIMATE AND WEATHER

It may seem hard at first to accept the fact that the arctic zone has much less variation in temperature than many sections of the temperate zone. But a single natural factor clears up the problem: water, with its ability to retain heat, acts as a stabilizing medium. The natural tendency of temperatures to decrease with the increase in latitude--that is, the farther north you go (and the farther south in the antarctic)--is offset in the arctic by the existence of the sea around the pole. Water acts as a radiator in winter, preventing temperatures from falling extremely low, and as a refrigerator in summer, keeping temperatures from getting very high.

A. Extremes of Cold and Heat

Thus, to find great extremes of temperature in the northern regions, we must find a combination of high latitude, distance from the sea, and low elevation. We find that the lowest recorded temperatures are found at those places which fulfill these requirements. The coldest spot in the world is around Oimekon, in Siberia, inland about 200 miles south of the Arctic Circle. Temperatures there drop to 90° below zero, which is more than 120° below freezing. The coldest record in Alaska and Canada is 79° below, at Fort Good Hope, 20 miles south of the Arctic Circle, and about 280 miles south of the coast. An explanation of Siberia's greater cold is that land extends farther north there; thus a place can be pretty far north, and still far enough away from the warming effects of the sea.

Correspondingly, to be hot in summer, a spot must be far from the moderating influence of the water. The Aleutians, surrounded by water, get neither extremely cold in winter, nor warm in summer. The warm ocean currents might have some effect on helping warm the land, if they did not create fogs in summer, which keep the sun from exerting its full effect. In summer, several hundred miles north of the Matanuska colony, which is near the coast and the fog-causing Japanese Current, is the land-locked Tanana valley near Fairbanks. Here tomatoes and wheat ripen better than they do at Matanuska. The extreme heat record for Alaska, 100° in the shade, was observed just north of the Arctic Circle at Fort Yukon, near the center of Alaska. Fairbanks, 100 miles south of Fort Yukon, has recorded 99°. Days with 90° are not uncommon. The same high temperatures are found inland along the Mackenzie River in Canada, and along the north-flowing rivers of Siberia. The "believe-it-or-not" fact that wheat grows regularly north of the Arctic Circle becomes easy to understand when we realize that low land areas far from the cooling sea become excellent wheat territory in the summer. In Canada, wheat is grown near Thunder River, 18 miles north of the Circle; in Siberia, wheat grows 100 miles north of its limit in Canada, but equally far from the sea, and also in a river valley.

Counterbalancing the cooling effect of the sea in summer, is the warming effect in midwinter. This comparative warmth comes both from the two currents, the Japanese and the Gulf, and from the

radiation of some heat from the arctic waters themselves, even through a film of ice. For this reason, it is unlikely that the temperature could fall below -60° F. at the North Pole; 54° below zero is the lowest temperature ever recorded on the north coast of Alaska. This is plenty cold, of course; but 250 miles south from the ocean in Canada it goes 30 degrees lower than on the shore; in Siberia, 600 miles south from the coast, it gets 30 degrees colder than on the shore.

B. Winds

There are violent local gales in the arctic, but in general, according to Nansen who drifted through the ice for three years north of Siberia, the northern sea is one of the most placid areas in the world. Near land, however, especially where there is a plateau descending to the ocean, there will be strong winds. There are strong gales down the slopes of Greenland, especially on the east coast, and fierce autumn and early winter gales from the north coast of Canada, around Franklin Bay and Herschel Island. The famous Aleutian "williwaw", springing up suddenly and changing direction quickly--"blowing three ways at once," pilots say--is a striking example of what our soldiers contend with.

C. Sea and Coastal Fogs

Fogs of the Arctic Mediterranean are found over open water, and over the ice area near the ring of open water. During the winter months, December through March, you will find practically no fog at all, when you are more than 200 miles from the nearest extensive marginal open water. At the meeting place of ice and water, the belt of scattered ice, there is much fog throughout the whole year.

Fogs increase in frequency at the ice pole from April to July, in which month about every other day is foggy. Toward the end of August, and from September on, the fogs clear up.

Along the coast, in both winter and summer, there is a great deal of fog, because of the differentials in temperature. In summer you may have temperatures of 90° above zero twenty miles inland, while the water is actually 2 or 3 degrees below the freezing point of fresh water--the sea freezes at 27° F., fresh water at 32°. Winds from the south pick up a great deal of moisture over the warm land, spotted with lakes, but begin to be chilled immediately they pass over the water. Wisps of fog develop only 100 yards from shore, and get thicker and higher as you get farther off shore. Five or ten miles off shore, the fog will be 200 or 300 feet deep. At about 30 miles from shore, the fog disappears.

Another type of fog occurs when cold wind blows in from the frozen sea over warm moist land. The cold air is quickly saturated from below and fog forms a short distance onshore. This fog is most dense several miles from the coast and may extend 30 miles inland. In these two cases, strong winds dissipate fogs and produce low cloudiness instead.

Arctic fogs are generally lower than those of the North Temperate zone. Pilots can usually clear bad weather at 15,000 feet. But farther south in the Bering Sea, and, as we all know, over the Aleutians, the fog is much harder to get over. In fact, pilots had to skim the water on their raids over Kiska to see anything at all.

D. Precipitation

In general, the Far North is a place of little snowfall and rainfall. In both arctic and sub-arctic, precipitation is heaviest in summer. Marginal areas, like the Bering Sea, the waters north of Iceland, and the Aleutians, "home of the worst weather in the world", have a great deal of precipitation at any time of year. The continents, away from the coast, and the Arctic Mediterranean, near the center, have very little rain or snow from December to March.

VI. LIFE IN THE ARCTIC

People in general, and indeed, many geographers, are just now accepting that there is a wealth of animal and plant life in the northern area, extending even up to the North Pole itself. The old myth of the lifeless North is pretty well shattered. Fish, seal, polar-bears carry on their subsistence cycles in the cracks of the polar ice just as they do farther south, and the Papanin expedition found by lowering sea-traps at different levels that the gradient of life, both of plants and animals, is similar to that of the North Atlantic.

A. The Zone Theory and the "Lifeless North"

The impression of the lifeless poles of the earth dates back to ancient times. The Greek philosophers had the theory of a symmetrical sphere, the earth, with five zones. The inhabited world as they knew it was in the north temperate zone. There was probably another temperate zone in the lower hemisphere, but men could never know whether this zone was inhabited, because of the burning torrid zone which lay between them, a region of heat which no man could cross, and live. At each extreme of the globe were the frozen zones. These regions were cold because they were so far from the sun, and its rays were so slanting. The great philosopher Strabo, who lived about the time of Christ, knew about Scotland and the Orkneys, and supposed that the dead region began just a bit north of these islands. The doctrine of the forbidding middle and extreme zones lost support in the fifteenth century, when navigators proved that the tropics need hold no terrors. Columbus, for example, was not afraid to suggest that it might be as easy to reach China by sailing north as by sailing west.

When people found, however, that there was much ice on the northern sea, and that Greenland, the Arctic land nearest to Europe, was covered with snow, the old belief in the lifeless north gained

new support. Thus the demonstration of the presence of animals and plants in the Far North was greeted with surprise. Explorers on Melville Island in 1819 assumed that the musk oxen they saw on the 75th parallel in summer migrated south to the forest in the fall. People thought that seals would not live far north in the sea; the small beasts on which seals live could not exist under the ice, because plants, the food of seals' victims, require light, and could not get sun through the floes. It was thought that Stefansson in 1913 was proposing suicide when his party went off to live by hunting in the Polar Sea, hundreds of miles north of land. When they returned safe, it was said that if they had gone farther north they would not have found seals to subsist on.

In 1937 the final death blow to the theory of the frozen and lifeless North came from the Papanin expedition. The party, deposited practically on the North Pole by plane, saw seals swimming around gulping down shrimps floating near the surface. This occurred when the ice cracked near the camp.

B. Vegetation of the Arctic

One of the distinguishing features of the arctic landscape is the vast areas of treeless, often poorly drained, lands known as the "tundra". The term "tundra" means a kind of plant cover. Between the great northern forests of North America and Eurasia and the cold deserts represented in the extreme by the Greenland Ice Cap, three imperfectly defined or irregular zones of tundra are recognized. Northward from the true forested areas is the bush tundra which consists of dwarfed or creeping forms of species that grow to larger size farther south. Beyond the bush tundra lie the large stretches of grass tundra which consist of a nearly complete vegetation cover of grasses with many other flowering plants mixed in. The third zone is the arctic desert tundra where the plant life exists only where there is adequate soil, water and shelter. The continuity of each of these zones is broken by the occurrence of the other types of tundra in localities too severe for the regional type. Thus arctic desert tundra occurs in the shrub tundra zone in Canada; while grass tundra is so well developed on the northern tip of Greenland that there is adequate pasturage for musk ox and caribou. Therefore, although one type predominates in a given region, the zones are broken up into a patchwork of all three types of tundra.

These varying belts of vegetation contain a much greater variety of plant types than is generally supposed. It is a great misconception to suppose that the most prevalent types are mosses and lichens. On the contrary, north of the Arctic Circle there are 760 kinds of flowering plants (grasses are included) as against 250 kinds of mosses and 330 kinds of lichens. One area where mosses and lichens predominate, around Churchill on western Hudson Bay, is several hundred miles south of the Arctic Circle.

C. Animals of the Sea

In the sea, the small animals eat the plants, and the large animals eat the small animals. The seal, for example, eats the shrimp, and now and then a fish; and the polar bear eats the seal. The walrus lives almost entirely on small animals, mainly clams. An exception to the general rule is that the largest animal, the whale, lives mainly on tiny animals and plants.

Only recently, within the last fifteen years, have we begun to find out much about northern fishing. The Soviet Union's exploratory campaign has uncovered much material on resources of the northern sea. A general principle of ocean study seems to apply: there is on the average least animal life in the ocean at the Equator, and, as you move away from the Equator, north or south, animal life increases until you have the greatest abundance in among the ice around the edges of the antarctic continent of the Far South, and in the chill waters of the North, as in the Labrador Current sweeping down to the Newfoundland Banks, and in the Bering Sea. It is not known to what extent the fish go in under the ice of the "inaccessible area" of the North; but it is likely that the Arctic Mediterranean will be found much richer in fish, per square mile, than the Old World Mediterranean.

D. Aquatic Mammals of the Pack Ice

The seal is the only large mammal that is found all over the northern sea at all times of the year. The walrus, being unable to make a hole in the ice for breathing, as the seal does, never goes far in among the ice. There is evidence that whales cross the Arctic Mediterranean in midsummer, especially the beluga, or white whale.

Polar bears have been reported in the water as much as fifty miles away from land, or the nearest floe; they can swim almost as fast as the average man can run, and they float so high in the water that it is easy for them to rest. The bear lives mainly on the sea, and catches his food there, practically all of which is seal. Both male and female bears go ashore occasionally to prowl up and down the beaches. As a rule the females go ashore to have their young.

If hunting is good the bear will eat little except the fat of the seal. He seems to eat as little of the muscle or protein as possible, or of anything except the blubber, and the skin that unavoidably goes with it.

The white fox always has its young on land, but perhaps two thirds of the number of foxes leave the land for the ice in the autumn. The fox is dependent on the polar bear for food: the bear kills seal, leaving part of the blubber and all the rest of the carcass. This is enough for several foxes for some weeks. The bear is thought not to eat more than one meal from every kill; the foxes remain until the seal is all eaten, then go search for another polar bear to follow, or for other seal carcasses.

E. The Land Mammals

The land mammals of the North are, in order of size, the musk ox, the caribou, the white mountain sheep, the wolf, the fox (white with its blue color phase), the arctic hare, the weasel, and the lemming. It is of course difficult to estimate the numbers of the various types, because of the broad uninhabited spaces, and the animal migrations. It has been estimated that there are in the northern Canadian islands and Greenland between 10 and 20 thousand musk oxen. There are in the North American area between 5 and 25 million caribou, a few thousand wolves, some tens of thousands of foxes, and only a few thousand hares.

1. The Musk Ox. Men and these oxen will seldom be found in the same area, because the beasts have an inadequate defense against spears, arrows, or bullets. A stationary, thin-red-line defense against wolves does not work against men. As a result the musk ox, which once inhabited land as far south as Kentucky, has been cut down with the northern advance of the forest Indian. Eskimos have exterminated the beast in North Siberia; and he has been cut down from Alaska to the East, so that now there are probably very few musk oxen west of Coppermine. There are still a few thousands of the animals on the Canadian islands, on the eastern part of the mainland, on the northern coasts of Greenland and on the Thelon Game Sanctuary between Great Slave Lake and Hudson Bay.

2. Caribou. These animals, also called reindeer, are found as far north as there is land, except that they have been exterminated on the north and east coasts of Greenland. There are vast caribou movements, some of which appear to be seasonal migrations. On some islands there seem to be more definite east-west movements than north-south. And in some sections the herds may move north in the colder months, south in the warmer.

3. Feeding Habits of Musk Ox and Caribou. The two animals offer a striking contrast in the distances they cover in search of food. The musk ox herds will move perhaps a couple of hundred yards a day, thoroughly grazing a grass area, resting when full, getting up to eat when hungry. It is said that a herd can usually be found within twenty miles of where it was the year before.

The caribou are restless and mobile. They move at the rate of a walk, two or three miles an hour, even while grazing. They are likely to stampede on the smell of a wolf, covering from a half mile to five miles before they stop to graze again. Musk oxen, usually so plodding, may stampede five or ten miles before they stop, once they get going.

4. Size of Caribou Herds

There have been several reliable reports during the last century of herds amounting to several hundred thousands, even a million. It is true that there are that many caribou in existence, but it is not likely that an Eskimo or Indian who lives by caribou

hunting will see more than a couple such herds in his lifetime. The gathering into large herds seems to be merely a matter of chance: the terrain, the guiding direction of watercourses and lakes, causing smaller herds to merge. Even these tremendous herds do not eat up all vegetation in their path: they move too fast.

F. The Life of the Forest

The arctic animals we have been describing live also in the sub-arctic; and there are a great many other species. There is the moose in the willows; the sheep in the mountains; the grizzly bear, 90% a vegetarian, living on roots; and the black bear. There are the flesh-eating animals that seldom go out to the tundra; the wolverine and lynx; there are the tree-climbing squirrels and chipmunks; commercial fur-bearers--beaver, fisher, marten, and mink. The bush rabbit supplants the northern hare. Most of these animals are not nuisances to man, though the wolverine, and all the bears will rob caches; and wolves can do a great deal of damage along the trap line.

G. Hunting in Prairie, Forest, and Seashore

Do not make the mistake of considering the forest a surer place to find food than the tundra. For most animals that live on vegetation, the grass tundra offers more sustenance than does the forest, since plants suitable for grazing animals will not grow in the shadow of trees, and only few animals, such as rabbit and porcupine and moose, can live off trees alone. The grass tundra supports many more animals for the hunter than the forest. The denser the forest, the less abundant the animal life. This is one reason why famine among local populations is more frequent in the woods than on the tundra. Famine is least common on the sea coast, because there animal life is more dependable--fish, seals, the walrus in summer, even whales.

H. Arctic Birds. Only three kinds of birds spend the winter in the really far north--the raven, the snowy owl, and ptarmigan. Most ptarmigan move a little to the south in winter, but many remain in the Far North. On the northern edge of the forest there is an influx of ptarmigan in fall and early winter from higher latitudes.

The rest of the northern birds migrate like clockwork. Most numberous of these are the waterfowl--swans, geese, and ducks. Eskimos kill geese by the hundreds when they are moulting, driving them over the tundra right into the village, and killing them there. There are rather few ducks and geese in the northern tier of the Canadian islands, those north of Banks, Victoria, and Baffin.

I. Insects of the North

A good illustration of people's lack of knowledge about the north is their surprise at learning of the variety and size of

insect life there. Somehow, insects are supposed to be killed off by the cold, or at least to be stunted by it. Northern summers are hot, and there is plenty of moisture around, in which insects can breed.

1. Mosquitoes. The only mild thing that can be said about the northern mosquito is that it does not transmit diseases. Its main menace is its bite and its numbers. Down the Mackenzie River, 100 miles north of Edmonton, you will be met by more mosquitoes per square yard than you have ever seen, except farther north. As you go north, the numbers increase. In the lake region north of the Great Slave Lake, toward the Great Bear Lake, the numbers are unbelievable. One writer, Ernest Thompson Seton, declared that he tested the numbers by holding his bare hand out for five seconds, killing the mosquitoes that began to drill it, and counting. On several counts he numbered between 100 and 125.

Mosquitoes bite at all times of night and day, and they do not seem to mind a reasonable chill. On the north shore of the Great Bear Lake, on the edge of the Arctic Circle, they start biting about the beginning of May, and are at their worst a month later. They are not bad in the remote north, becoming less numerous in the second tier of islands, such as Melville -- not much worse than in New Jersey, as Stefansson says. Also, they are seldom bad within 300 or 400 yards of an ocean beach in the Arctic.

2. Sandflies. These pests, also called no-see-ums and punkies, are so small that they can get within the mesh of an ordinary mosquito net; they will get inside clothes and move around like fleas. Thus it is important to have knitted underwear that grips tightly at wrist and ankle. The sandfly does not bite at night, or on a cool day; but it is hardly ever dark enough during the summer to convince the flies that it is night.

3. Other Insects. Besides the sandfly, there is the so-called bulldog fly, which looks like an oversize house fly and stings like a needle, and draws blood at each bite. This fly is bad about a month or six weeks in midsummer. There are other biting flies, about the size of house flies.

There are also butterflies, dragon flies, beetles and a number of other insects. Peary reported bumblebees within a few yards of the most northerly land in the world, named after him, the tip of Greenland.

4. Protection. Clothing, netting, and insect repellent are the ordinary requirements to protect against bites and stings. Because of the smallness of the sandflies and the drill of the mosquitoes, it is necessary to wear outer clothing thick enough to foil the most ambitious mosquito, and underclothing tight enough at wrist and ankle to keep out flies. Also necessary are gauntlet gloves to protect hand and wrist, and leggings for the ankle. Broadbrimmed hats are necessary, with netting kept close around the crown with elastic, and tucked in around the collar. All in all, in some parts of the North you are likely to suffer from the heat as much as anywhere else in the world, because insects will not let you dress lightly or go swimming, and because the Midnight Sun prevents the coming of night in which to cool off.

There are several kinds of insect repellent, both G.I. and commercial. They are undergoing continual improvement, for effectiveness and staying power. A good application to face or hands will last a couple of hours.

It is believed that men and dogs develop a kind of immunity to mosquito bites. The first summer of exposure to bites, there will be extreme swelling. Bites around the eyes of dogs may swell so that the eyes are closed; dogs have been stung to death by mosquitoes. The second year of exposure, the swelling is slight. The third year, there is practically no swelling. But the pests keep on biting and drawing blood.

VII. Human Life and Settlement

The Great North is sparsely settled. The Eskimos and Indians, the two types of native populations, never were numerous, and since their contact with the incoming white man, have decreased in numbers. First, introduction of white men's ways of living has caused a loss in independence and in the natives' mechanical proficiency in coping with nature. They have lost some of their hunting skill, as, for example, in the ability to kill whales; and in accepting white man's dress and types of dwelling, they do not always change for the better. Second, contact with white men has brought disease which the natives are ill-equipped to fight. An illness like measles, comparatively minor for whites, was at first a deadly scourge for the Eskimos. This weakness, incidentally, is also encountered among natives in the tropics, where as many as half or three-quarters of a village might be wiped out by the first measles epidemic. And of course the white man's alcoholic liquors have a weakening effect on many of the natives, who seem not to be able to take it or leave it alone.

A. The Eskimos. These Mongoloid peoples probably first came to the Western hemisphere from Siberia. They moved across the narrow Bering Strait in their skin boats sometime between 4000 and 2000 years ago. From Alaska they moved east. There were probably no Eskimos in Greenland more than 2000 years ago. All we can know of this is that when the Icelanders (of mixed Irish and Norwegian descent) started colonizing west Greenland after 982, the Eskimos had been there before them; none were seen by the colonists, but the sagas describe remains which are clearly of the Eskimo type. The first Eskimos actually seen and reported by Europeans were met by the Icelandic Greenlanders when they sailed to Labrador, just after 1000.

It is likely that at the time of Columbus there were in North America, from Alaska to Greenland, from 100,000 to 200,000 Eskimos. Today there are about 50,000. About 18,000 of these are in Greenland, less than 10,000 in Canada and Labrador, somewhat more than 20,000 in Alaska, and 1000 or 1500 in the extreme northeast of Siberia. (These Siberian Eskimos probably migrated back to the continent of their distant ancestors, having left Alaska within the last few hundred years.)

In Alaska there are now more whites than Eskimos and Indians together--just before the war there were 40,000 whites, 11,000 forest Indians, and 20,000 Eskimos. But this is the only part of the New World in which whites are more numerous. The ratio of whites to Eskimos is

smallest in Greenland--400 to 18,000, where most of the whites are government officials. The whites in the rest of the Eskimo world are missionaries, traders, trappers, prospectors, and some government employees, such as the Royal Canadian Mounted Police.

Until fairly recently the Eskimos had only a small number of permanent settlements, and these chiefly where there was good whaling, as at Point Hope or Point Barrow in Alaska. There were, however, some localities where the Eskimos could be expected to turn up at certain times of the year; people went down to the coast for winter hunting of seals and spring whaling, and inland for summer and autumn hunting of caribou and other land animals. But recently this nomadic independent existence has changed. Eskimos gather around the trading posts on the Mackenzie, when summer river steamers start moving soon after the ice goes away. Many of them, devout Christians, gather around mission stations to attend church, at any time of year, and are rewarded by gifts of food by the missionaries. This has led to the "pauperization" of a great many natives, who have come to depend on charity.

Hunting and fishing are still the main occupations of the Eskimos, except near certain mining towns in Alaska. Greenland Eskimos live mainly by sealing, but well north along the west coast they get walrus and polar bear. In some localities white whales are hunted; in a few places birds and their eggs are important foods.

All the islands of the first tier north of the Canadian mainland are inhabited, while there are very few Eskimos north of Victoria, Banks, and Baffin. The northern islands were at one time inhabited more thickly; ruins discovered by Stefansson on Melville Island were probably a number of centuries old. Eskimos can be expected to gather, in addition to their regular hunting grounds, wherever there are Hudson's Bay Company posts.

The means of subsistence vary with the terrain and wealth of animal life, and the time of year. Sealing, fishing, whaling, caribou, and mountain sheep hunting all supply life, but there is also a growing dependence on white man's foodstuffs.

B. The Indians.

Up the Yukon in Alaska, and Mackenzie in Canada, and in the surrounding forest, live the Indians of the Athabasca stock. Their method of life has been changed less than that of the Eskimos by contact with the white man, mainly because the inland region had less to attract white men than the northern tundra. In the forest are trading posts and missions around which the people gather, especially in summer. In winter most of the people go off to hunt and trap.

In former times there was less security of food in the woods than farther north. Forest famines were of two kinds: simple lack of food, and lack of sufficient variety. "Rabbit starvation" is a term applied to the food situation in which there is plenty of lean meat available, as in hares and skinny moose, but not enough fat to maintain health in the body-heat-consuming north.

C. Attitude of the People

Any traveler can expect assistance from either Eskimos or Indians. Indeed, they are much more hospitable than the average white. Eskimos are usually more generous and outgiving than the Indians, but this is because the latter are less likely to have food to spare, living just about on a subsistence level. With increasing relations with whites, both races, Eskimo and Indian, are learning to be more calculating about their hospitality, and more selfish.

D. Eskimo Shelter and the Snowhouse

Although the dome snowhouse, or igloo, is an Eskimo invention, many Eskimos have never seen one. The snowhouse has been used to good effect by several American explorers--Hall, Peary, Stefansson, MacMillan. It has the advantage of being fairly easy to build, and easy to keep warm. The snowhouse is used mainly by natives of northern Canada and the islands off the coast. In northern Alaska, when snow houses are used, they are likely to be makeshift rectangles, with snow walls, and snow roofs supported by rafters. In the Aleutian Islands, houses are of earth and wood. Other localities have rude shanties; or frames of wood and whale-bone heaped over with earth; or, in the forest, willow frames spread over with skins, with moss or grass as insulation between the layers of skin.

Tents are made of skin in all Eskimo sections. In some places they are tepee shaped, in others A-shaped. The inland Alaskans also have tents with an inverted willow basket frame. The forest Indians have both houses of the willow frame type, covered with skins, and the tepee, used both summer and winter.

E. The Comforts of Life

In their own native styles, the Eskimos are much better protected from cold than the Indians. The Eskimo snow house or earth hut is much better fitted to keep out cold than the Indian tepee. The Indians need a great many blankets to keep moderately warm, while the Eskimos farther north can take off all their clothing and still sweat, with a blubber lamp furnishing both light and heat. The secret seems to be in insulation and the placing of the entrance in the floor, so that warm air cannot escape without specific intention of the residents. The tendency of the Indians has been to adopt blanketing and woolens, which alone are not sufficient to withstand extremely cold weather, while the Eskimos retain their reindeer skins. Indians have benefited from the introduction of the white man's stove and cabin, but the Eskimo, desiring to be fashionable, with a wooden cabin and a door in the side, loses by the exchange of his own for the white man's type of dwelling.

On the other hand the Eskimo has benefited by white man's technique of dealing with summer. Canvas tents are better than skin tents--lighter, more compact, and not liable to decay when wet. Knitted underwear helps keep out sand flies, which used to crawl about under the loose skin clothing. A mosquito head net protects the face during the day; a bed net permits sound sleep at night.

VIII. THE MAINTENANCE OF HEALTH

In several ways maintaining physical efficiency is simpler in the North than elsewhere. Depending on the region, infection is less likely to set in from cuts or scratches. In most of the open spaces, inhabited rarely by groups of men, such dangers as tetanus are negligible, simply because the germs do not exist there. Mosquitoes may suck blood, but do not transmit malaria or yellow fever. While wounds may not become infected so readily as in tropic or desert, there is danger, as we know from reports of Russian winter fighting, of freezing of wounds.

A. Infections

Diseases which depend on the human body for transmission, such as tuberculosis and typhoid and measles, have the same effect as anywhere else. Even in the cold north, water taken from near human habitations should be purified. Colds occur in about the same proportions as under similar conditions in the United States.

B. Snowblindness

This is probably the only physical ill which is more dangerous in the arctic than anywhere else. There is no such thing as developing immunity to this affliction. Once you have sustained snowblindness, your eyes will be more sensitive to the white glare. To prevent an attack, the important thing is to limit the amount of light that enters the eye, or else to filter the light. Painting the nose or blackening the face may be of a little value in keeping down reflection, but the important thing is to wear glasses. Green or amber colored glasses help distinguish between high and low places on a snow surface on an overcast day, a distinction that is hard to make without glasses or with other lenses.

C. Poisonous Foods

There are not nearly so many sources of poisonous food in the arctic as in other regions of the earth. There are almost no poisonous plants, for example, apart from some toadstools; and no poisonous fish. Two possible foods are considered poisonous, but not without reservation. First, some mussels have caused illness, in southwestern Alaska, on Hudson Bay, and in southern Greenland. But the danger is by no means universal, and perhaps exists only at certain times of the year. Second, polar bear livers are poisonous if eaten in appreciable quantities and should therefore not be eaten at all.

There is a similar doubt about the exact cause of illness and death from eating whale meat. Stefansson thinks the trouble may come from fresh muscle meat, insufficiently cooked, rather than rotten meat. The deadly agent is not weakened by freezing.

D. Frost and Snow

The most important warning in this connection is to analyze "Common notions", which may very well turn out to be superstitions. For

example, the notion that "like cures like", cold cures the effects of cold, has probably caused the loss of more noses and ears and toes than the frost itself. When a part of your face is frozen, putting cold snow to it usually means making the part still colder, since the snow may be colder than the air. And rubbing with snow means irritating frozen tissues.

To treat frostbite, the main thing is to raise the temperature of the frozen part, slowly. Usually the most convenient warm thing is the palm of a hand. If such warmth is held to a frozen part which is as yet no larger than a dime, and no deeper, the skin of the face will not even peel. If the spot is the size and thickness of a nickel, there may be peeling, as from a mild sunburn. Only if the spot is bigger than a quarter will there be a blister; and there is no excuse for letting it get that big. Even if there is no one to warn you, you can make yourself aware of frozen spots by continually making faces. A stiffness of the skin will make itself felt immediately.

Another mistaken theory, in contrast with the snow treatment, is that the frozen part should be thawed with water so hot that it is just below the scalding stage. This is utter nonsense, based on the false notion that the longer the flesh remains solidified, the broader the injury. It is true that a section of flesh frozen for an hour is more likely to die than the same part frozen for five minutes, but small areas of tissue can be frozen for some time, without spreading gangrene, once the freezing is brought under control. And the difference of time involved in bringing up the temperature gradually is so slight that the flesh remains stiff for only a slightly longer period, and with less danger from too sudden thawing.

Another bit of folk nonsense is that anything which does not harden with cold is not really cold, and will draw the cold out of a frozen part. Thus unwarmed kerosene has been used to "thaw" frozen feet, usually with the result that the whole limb is lost, rather than at most a toe or two. Liquid air is not solid, but it is awfully cold!

Grease on the skin, for similar reasons, should not be used to keep cold air away. It may make the face colder. Another reason is that the grease may be transferred to the clothing, and where the grease touches fur or wool, it penetrates into the air chambers, and solidifies the material. This breaks up the insulation; a greased area of clothing is a good conductor of heat, or cold.

Another quaint notion, about which the Eskimos have more sense, is that you should not eat snow. It should, in fact, be nibbled at the first sign of thirst, or better, before thirst sets in. It must be taken in small bits, or licked from the hand, like sugar or salt, after you have breathed or blown on it, to warm it a bit. Better still, if you are well dressed and your body is warm, take off your mitten long enough to roll up snow in your hand, so that it becomes slushy and soft. You will get more of it at a time, and it will be warmer when you swallow it.

Do not lick things in cold weather. The tongue will stick to anything larger than a small piece of ice. The object will draw heat rapidly from your tongue, and make it freeze to whatever it touches. If

the tongue sticks to a small piece of ice, try to take the whole piece into the mouth, to melt it and release the tongue. If you make the mistake of touching something larger with the tongue, then you need the courage to pull your tongue away and lose a piece of skin. So chop ice fine before you start to eat it. Not only the tongue, but the skin of your hands or any part of your body will freeze to cold objects, such as metal tools.

Do not wait until you are really thirsty before you start eating snow; then you are likely to gulp it too fast, or try to eat too large a piece of snow or ice, thus chilling your stomach.

Do not be afraid to expose your body to extreme cold, even 50 or 60 below, in calm weather for a minute or two. The skin retains enough heat about it to prevent chill. Eskimo women put naked babies on a skin in the snow for as much as half a minute before the baby begins to notice that the air is cold, and starts to cry.

Another exploded theory, probably the cause of the deaths of many white men, is that if you get lost in cold weather you must not go to sleep, lest you freeze to death. It is true that a man can freeze while unconscious in the snow, but only after he has so tired himself by struggling to keep awake and moving that his body cannot receive the warning that it is cold. Another danger of trying strenuously to keep awake is that you are likely to perspire; this perspiration will condense, and freeze.

The Eskimo simply sits down with his back to the wind, hunches forward, and goes to sleep. Sleep helps pass the time, and economizes body energy. You will feel chilled soon enough, even while sleeping, just as you will at home on a cold night with insufficient covering. At that time you do not simply freeze to death; you just get up and get more blankets, or close the window. When you awake after a short nap in the snow, even only five or ten minutes of it, you will feel refreshed; to get warm, start moving around moderately, but not so quickly as to raise perspiration.

You cannot harden yourself to the cold; that is, the body does not build up resistance to cold. As a matter of fact, the idea has been proposed that dwellers in cold regions adapt themselves to the cold by feeling it sooner, and developing colder skins, rather than developing a resistance to the sensation of cold. This adjustment of course permits a quicker adjustment of clothing, and a protection against too great loss of body heat.

There is no racial difference, so far as is known, in the ability to stand cold. Matthew Henson, a Negro, was Peary's best traveling companion; and old New England whalers used to say that those of their crews who were southern Negroes or South Sea Islanders might dislike the first winter of a three year voyage more than the whites; but after a second winter, as a group these men had no more difficulty than any other national or racial group. This is just another indication of the adaptability of man; with the right will and understanding of a situation, he can master almost any physical condition.

IX. ON LIKING THE ARCTIC WINTER

It might be said that most people dislike the arctic during their first winter, and that few dislike it after their third winter. A simpler statement to accept is that those who were born in the far north, or who have lived there some time, will complain no more about the climate than do people elsewhere. Further, more than half of any large group of whites, and probably 90% of Eskimos, will declare that they like the winter better than the summer. Some years ago a judge in the Nome district in Alaska took a vote of Nome schoolchildren, and found that about two-thirds of the children preferred winter to summer. In November, 1940, the question was asked of Fairbanks schoolchildren which they preferred, January or July. July in Fairbanks is much the same as in New York or Minneapolis--the highest Weather Bureau record is 99° in the shade. In winter the lowest temperature is 70 below zero. The tabulation of votes shows a clear preference for winter over summer. In the elementary grades January was preferred by the boys 105 to 57; by the girls, 86 to 58. In high school 34 boys preferred July, 21 January; but the girls restored the balance for winter, 32 to 23. On home discussion, it turned out that the parents of the children shared their preference for winter, women more pronouncedly than men.

The conclusion seems sound: adjustment to new physical surroundings may be not only a military necessity, but also an actual source of pleasure.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE ARCTIC (THREE LECTURES)

A II. LECTURE II—MAINTENANCE AND OPERATIONS

Prepared by

U.S. THE ARCTIC, DESERT AND TROPIC INFORMATION CENTER

OFFICE OF ASSISTANT CHIEF OF AIR STAFF, INTELLIGENCE
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ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
ARMY AIR FORCES

* * *

School Lectures

No. 2,

THE ARCTIC

Lecture II:
Maintenance and Operation

No longer is it a secret that in 1940 the Army knew very little about fitting planes for arctic flying. Yet today our flyers drop bombs on Paramushro, Japan's northern base: and the Aleutian Islands shape up more clearly every week as the dagger toward the heart of Japan, as flying goes on both summer and winter. Our flyers and ground crews have learned to overcome the extreme cold of continental Canada, Alaska, Labrador, and Greenland on the routes to the combat areas, and the vicious winds, fogs, and rain of the Aleutians, which are less cold than the mainland but more dangerous for flying.

This striking change in situation is the result of magnificent energy and plain hard labor. The fact that planes get off the ground at all in arctic and sub-arctic cold is a tribute to the ingenuity of aircraft designers and the perseverance of Army Air Force ground crews. Where all maintenance work must be done through gloves, where touching a tool with bare hands for even an instant may mean loss of skin, where engines may have to be heated for an hour before they can even be turned over, the planes are nevertheless ready to take off when they are needed, and pilots trust their ships.

Maintenance and operation of aircraft in cold regions are not easy, but neither are they hopeless tasks. Procedures have been worked out for getting a plane into the air and keeping it flying, so no longer is cold alone a factor in preventing operations. It requires a combination of bad visibility, storm, and icing to ground a plane. As far as human effort can go, our men will be prepared to go. Therefore, to make this effort fully efficient, it is necessary to learn now what some of the problems are, and to get an idea of some of the methods used to solve these problems.

This material is not intended as a substitute for a T. O. Nor can it do your work for you. It can help give you an idea of what to expect, and a degree of confidence, if you are called upon to work in the north. We must not blame failure of equipment on gremlins or some mysterious alchemy induced by cold. Most arctic flying difficulties can be traced to a failure to follow maintenance and operation instructions.

Part I--MAINTENANCE

Three broad principles lie at the basis of proper arctic maintenance --as, of course, at the basis of all maintenance. First is a knowledge

of the problems that exist, peculiar to the climate and location. Second is a knowledge of the devices and measures required to solve these problems. Third is the determination to take proper precautions, and to put knowledge to use. This last factor requires qualities of spirit and devotion without which all knowledge is useless for accomplishment of a tough and vital mission.

I. WINTERIZATION AND MODIFICATION

Aircraft are ordinarily constructed to operate at moderate temperatures, and materials used are adequate for these conditions. But as soon as operations are undertaken at unusual temperatures, such as in the extreme cold encountered in the far north, or at great altitudes, some changes must be made. One way of meeting the new problems would be to introduce completely new equipment, different kinds of structural material, perhaps, or new lubricants, new fuels, and new engines. But not all such departures have been found necessary. Once the basic principles of operations in unusual conditions are understood, it is found that certain "modification" of the basic aircraft will be sufficient to fit it for its new duties.

The fundamental problem in cold weather operation and maintenance of aircraft, just as it is for human life, is to conserve heat. In the tropics and in the temperate zone the problem is to get rid of the products of combustion, such as engine heat and body heat, without interfering with the functioning of the organism. In the north, or at great altitude, where temperatures are extremely low, something must be done to save this heat and put it to use. Human beings use well-insulated clothing that holds in body heat. Corresponding practices applied to aircraft utilize engine heat to combat the cold. Also, in other ways, craft must be fitted to operate at a level of temperature as much as 100°F. below temperate zone conditions.

The methods and devices employed in "modifying" craft for northern operation are summed up in the term "winterization". "Winterization" involves such processes as keeping oil in a fluid state; combating ice-formation on surfaces, and in the carburetor; preserving mobility of controls and prop-feathering apparatus; arranging batteries to meet increased electrical power demands; and preserving efficiency and comfort of personnel. Specifically, winterization prepares planes to function between -65°F. and +160°F.

The more work done on planes before they get to the tactical squadron, obviously the less remains for the crew chief to worry about. The best place to prepare materiel for specialized operations is the factory itself, where, by some modification of the basic design, resistance to climate is built in. This winterization can also be carried on at "modification centers", of which there are a number in continental United States, and at air depots. At northern stations winterization kits should be requisitioned well before the approach of extreme cold, and T. O. instructions rigidly complied with.

A. Elements of Winterization

1. De-Icing and Anti-Icing: Equipment for this important phase of winterization includes pneumatic boots for wings, vertical fin, and stabilize

propeller anti-icing plumbing and slinger rings, and electrically heated propellers, etc. The compartments of pilots and bombardiers are equipped with windshield wipers and heaters, and some have alcohol sprays. There is also available a heating system for the carburetor. Modification of the induction system may include alcohol de-icing and the heating of scoop inlet air.

2. Heating: Modification of aircraft will emphasize this important detail. It is to be expected that some new craft will be "hot wing" jobs, with wings, empennage, and cabins using a unified heating system, adding greatly to comfort and safety. There will be cockpit, cabin, and turret heating for all planes. Carburetors will be equipped for heat application and provided with carburetor air thermometers.

A recommendation for bombers and transports is the double panel-heated windshield. Available for pilots, bombardiers, and turret gunners will be blast tube heat. Special heating will be provided for some engine accessories, for automatic pilot, bomb sight, camera, guns, instrument panel, and pitot head. Immersion heaters for the preheating of engine oil in the tank have been provided for some planes, and sockets for plugging in 110-volt external current source; but current practice favors flexible electrical heaters as ground equipment, and ground heater accessory doors on each engine nacelle. Protection by lagging may be necessary for long lines, propeller governors, and external scavenger lines.

3. Mechanical: The control system will have provision for differential contraction and expansion. Gear-type pumps will be installed with adequate clearance to compensate for the case shrinkage. Other installments will be surge valves or self-thawing tanks, condensation traps and drains in oil and gas tanks, standpipes in tanks, safety vents protected from outside temperatures, and large oil drain plugs. Fuel and oil tank drain cocks must be accessible, and must permit a positive lock without safety wire. Oil lines will be installed to enable complete drainage. Hazardous screens must be removed from the carburetor ram. Other positive necessities are a clear vision window for the pilot, nose shutters, spoiler rings and oil shutters on some transport craft, oil and coolant shutters with full-closing cowl shutters on most craft; and full-closing intercoolers for turbo-supercharged craft. There must also be provision for diluting oil.

4. Electrical load, increased by night flying and heating requirements, will be carried by larger batteries. As much as possible of the current needed while the ship is on the ground will be supplied by external battery cart. Plugs will be arranged for this with a spring-loaded door to permit removal of the power line without subjecting lineman to prop blast. Plugs for wired flying suits will be in accordance with T. O. instructions. There will be a high capacity ignition system and booster coils; turret motor output will be increased.

5. Hydraulics: All hydraulic fluid must be changed to cold weather specification grade. Hydraulic packing, hose connections, diaphragms, cups, and seals must be of materials which will not become brittle and must remain pliant and resilient, and will not rupture. Pneumatic hydraulic shock absorber struts will have a combination of leather and synthetic rubber packing rings, installed with metal adapters. Wheel brakes will be equipped with low temperature synthetic rubber seals or expander tubes.

6. Lubrication: Engine oil must be cold weather specification grade. All lubricated surfaces must be cleaned and re-treated with approved oils and greases. Non-channeling grease will be used where prescribed for the elements of the control system. The propeller will be lubricated with special grease. Light oil will be worked into the oil pressure gauge line where direct-reading is employed.

7. Miscellaneous: Fabric covers for engines, props, wings, tail surfaces, windshields, turrets, and possibly carburetor air intakes should be available. Snow and ice surfaces demand special tires to afford additional grip, and these require careful check of clearance in the stowage wells. Check clearance also on retractable landing lights and undercarriage, flaps, and air brakes. Guncharger hose must be winterproof; gun bays will be insulated in some cases, heated in others, and barrels will be closed with Scotch masking tape, cleared by the guns firing. Circulation of warmer oil will be induced in the breaker boxes and in the hydromatic propeller dome, by drilling oil passages where necessary. Openings will be carefully sealed against drafts, and the sealing strips oiled with a non-freezing grease. An oil dilution system will be provided, and propane starting facilities may be installed. A clear vision window will be provided for the pilot.

Units of equipment which have been modified for operation at -65 to +160°F. (-54 to +71°C.) will be marked with a yellow dot, not smaller than a quarter inch in diameter. Lack of the dot does not mean lack of approval, but merely that the material has not been thoroughly tested. A white dot indicates tentative approval.

B. Personal Factors

Modifications and winterizing procedures are only the beginning of the process of keeping planes flying in the north. Proper maintenance procedures and sensible personal care are equally important. Follow rigidly the rules laid down for cold weather maintenance and operation. Get to be "cold-conscious"--learn the properties of cold, and its effects on personnel and machines. Some fear of the unknown is inevitable; so know more and fear less.

Aircraft can be and are successfully maintained in extreme cold. The job is tough, and downright uncomfortable much of the time. It takes some ingenuity, but the main need is common sense to get the job done while avoiding the discomforts of cold and frostbite. The handicaps may tempt you to fix all blame for mechanical failures on the cold. Such ideas cause bad work.

II. FACTORS OF PHYSICAL DISCOMFORT

Work in cold weather takes longer. Physical discomfort, difficulty of manipulation of tools, possible decreased visibility combine to demand patience and good nerves from crew men. Simple operations like applying safety wire or checking valve clearances may be heartbreaking experiences, because the choice is between two evils: either you risk metal-burned or frozen fingers, or you wrestle with awkward pliers in a bulky glove. Yet such work must be done, if our planes are to fly and fight in arctic weather. Proper clothing and simple common-sense precautions can reduce discomfort and inconveniences.

A. Clothing

The problem in cold weather maintenance work is to keep warm and yet be able to work efficiently. In a word, warmth without bulk. Heavy clothing for work on the line in bitter-cold weather is a handicap, exhausting physically and mentally. The importance of proper clothing cannot be too strongly emphasized; footgear and gloves, especially, require attention.

1. Footgear: This cannot be both warm and waterproof at the same time. Waterproof material both causes condensation of body moisture, and acts as a conductor of heat, rather than as an insulator. Yet the secret of effectiveness in the north is to keep both warm and dry. The mukluk issued is the most practical and serviceable footgear for extremely cold weather, in which the snow is dry. In warmer weather, of course, when slush is on the ground, rubber waterproofs are necessary. For complete protection, the arctic wardrobe should include at least 3 pairs of mukluks, and the several pairs of inner soles and socks which go with each.

2. Body Clothing: At present, two outfits are in process of issue: a quilted down-filled suit, wind resistant and buoyant, for use in extreme cold; and a two-layer suit composed of an intermediate and outer suit made of wind-and-water-repellent cloth lined with alpaca, both layers of which should be worn in extreme cold. Underclothing should be worn loose; several layers of light underclothing, affording air spaces, are warmer than a single, heavy weight layer. Outer clothing should be wind-resistant, but not waterproof.

3. Handgear: Gloves are, of course, the most difficult order to satisfy. Warmth ordinarily requires bulk, and bulk prevents the application of nimble fingers necessary for work. A satisfactory compromise is to use basic light cotton, silk, or rayon gloves, plus the D-3 mechanic's glove. This latter consists of a horsehide outer shell with a removable knit-wool inner lining, hung around the neck by a thong, and used as a warming muff when required.

4. Headgear: Any parka hood, correctly fitted and properly lined, will serve. It is important that the parka hood be snugly fitted, and that a strip of naturally oily fur, such as wolverine, be attached around the facial aperture. This will prevent the wind from entering at the sides; the frost which accumulates on the fur can be brushed off with ease. An important general requirement of headgear is that it cover the ears, which are easily frozen. The woolen toque, and the ski-cap, are other kinds of headwear.

B. Precautions

1. Avoid Overexertion: With temperatures at -25° and below, there is danger of chilling the upper respiratory area through heavy breathing during overexertion. If you find yourself gasping large breaths of air, put your head down and breathe from inside your warm clothing, until you can breathe normally again. Overexertion also leads to depletion of energy, and chill of the body.

2. Avoid Sweating: Sweat will condense within clothing, and freeze. Keep removing articles of clothing as body temperature goes up. Damp

portions of your body will freeze quickly. Take every opportunity to dry out your socks and underclothing. Always change as soon as you can when your body gets wet. If you perspire indoors, dry your body or change and dry your clothes before you venture out in severe cold weather.

3. Gasoline spilled on the hands or clothing in sub-zero temperatures has an effect similar to liquid air. It will freeze flesh a few seconds after contact.

4. Don't touch cold metal without gloves: The moisture of your skin will freeze to the metal surface, or the cold metal will freeze the part of the hand in contact with it. An attempt at forcible separation will rip off the skin. If you should get stuck, warm up the metal before attempting to release yourself; an emergency method is to urinate on the point of contact.

5. Insulate your tools with velour covers or wrap the handles with twine. Choose tools which lend themselves to cold weather use; i.e., single-ended spanners and wrenches. Also cover all control handles in the plane itself.

6. Avoid prop wash; assist each other if exposed to it, by checking for gray or white areas of frostbite on face. Thaw by placing a hand or warm material over the frozen area until circulation is restored. DO NOT RU

7. Keep as clean as possible: Oil and grease on your clothing will reduce the insulating qualities of the fabric; also remember that laundry facilities are limited.

III. NEUTRALIZING NATURE

Merely sitting idle and waiting for action, a ship can develop dangerous qualities. Its wheels can freeze to the spot, frost can develop, snow can lie on the wings in wait to cause trouble.

A. Parking and Mooring

1. It is advisable that the parking area for wheel gear be sanded, or that grating, steel mat, fabric, grass, straw, green boughs, or other insulating material be placed under the wheels to prevent freezing to the surface. Failure to exercise such precautions frequently results in the tearing off of large chunks of rubber when the plane is moved.

2. When planes are parked, expander type brakes should be "OFF" for a half hour to prevent locking by ice formed by condensation, then placed ON. Other types should be left ON. Flat-based wooden chocks will not hold on snow or ice surfaces. Metal tube chocks, preferably with spurs, are better. Block the wheels fore and aft.

3. Mooring arrows provided in the plane mooring kit should ordinarily be used. Mooring is necessary because of the sudden winds which may spring up. If no fixed anchorage is available, and the ground is frozen too solid for use of mooring arrows, a variety of "dead-man" mooring is necessary. Dig holes in the ground below or adjacent to the mooring points of the plane, and freeze hanks of rope, or stakes in them. The ground may have to be heated to permit digging of holes.

4. Mooring anchors of other types may be improvised. For parking on ice, two holes can be dug a foot apart, and a hole drilled through the solid ice between the dug holes. The mooring line can be carried through the connecting hole. On an ice-covered lake, if the ice is not too thick, chop a hole through, drop a log with the rope around its middle through the hole, then jam the stick crosswise under the ice, and keep it tight.

Mooring lines should be tight to prevent the craft from rocking in the wind. A slack line is of little value. At permanent stations, mooring bits should be installed during the summer. Controls are locked with surface control locks, rather than with the locks of the control cable system.

5. Nose hangars facilitate greatly the maintenance of tactical craft in cold weather. These may range from small, improvised structures, patched up of frame and canvas, to large, elaborate installations, built on skids or permanently located. The permanent structures are floored, solid-framed, insulated, and heated, fitted with tool benches and storage room, with one side composed of canvas openings equipped with draw strings. Through these openings intrude the plane's nose and engine nacelles. This arrangement makes an acceptable hangar for all normal cold-weather maintenance. Types are available to accommodate one, two, and four-engined craft. A make-shift shelter of tarpaulins can be rigged. Lighting must be arranged.

It is good practice to provide a rink of glare ice near the nose hangar to facilitate moving the craft in and out. If tractors are not available, anchorages for block and tackle should be laid in the ice to permit moving by a small crew.

6. Sweating: For tactical craft operating in cold weather, outside parking has been found desirable, even though hangar space is available. Cold aircraft wheeled into a warmer hangar will sweat, as moisture condenses on the cold plane surfaces. If not thoroughly dried through a process requiring the better part of an hour, with all areas vented, the plane will fog up upon being returned to the outside temperature, and considerable takeoff delay will ensue. The necessity for dispersion of craft in some areas makes outside parking mandatory, of course.

7. Frosting: When a ship is parked for the night, either the emergency escape hatch or some other opening should be left partly opened. This will permit circulation of air inside the cabin or cockpit, and so prevent the frosting up of the windows which is certain to occur in cold weather if air does not circulate and prevent moisture from settling. Beware of falling and drifting snow, however.

8. Covers are essential to arctic operation, and care must be exercised in their use. There are covers for engines, wings, tail surfaces, windshields, propellers, turrets, and air scoops. Putting covers on wings is fairly easy if they were folded properly when last removed. On fighter craft the covers can be installed by one man. Three or four men, however, are needed for bombers. Covers are tailored for each plane. Most of the work must be done on hands and knees, lest there be damage to the wing surface, especially the wing tips, which are not designed to carry loads.

Care must also be taken with the de-icer boots, which are easily damaged. Cover tie-down ropes should be fairly tight to prevent whipping in the wind. The older-type wing covers require slip-knots for easy removal with gloves on. Newer covers are easily installed and removed with a pulley and block arrangement.

On removal, before covers are folded all snow must be removed. They are carried in the plane, and cabin heaters may melt the snow, which will freeze when the heat is turned off. Tears should be mended immediately.

B. Removal of Snow, Ice, and Frost

Condensation anywhere on a plane can cause trouble, varying in seriousness with the part affected. You can neutralize this dangerous factor by getting the habit of certain check-ups, and by knowing how to prevent frosting.

1. Frost will frequently be found covering an aircraft. No matter how thin the layer may appear, it must be removed, especially in the vicinity of the wing tips, where it can most seriously disturb the aerodynamic qualities of the wing. The simplest method is to sweep the surface with a stiff broom, preferably one with a long handle. Hoar-frost will usually form just as the sun is rising, on aircraft which have been dispersed in the open overnight. Investigate for it before takeoff. And we know that craft wheeled from a warm hangar will usually accumulate frost as soon as it gets outside. Loss of lift and treacherous stalling characteristics can be caused by a very small amount of hoar-frost, which will seriously disturb the airflow over a wing.

Under some conditions, notably with ground haze, frost will form so rapidly that it will be necessary to taxi out to take-off positions before removing covers. Mopping the wings with alcohol and glycerine before covering will delay frost long enough to permit takeoff when covers are removed.

2. Snow or ice must also be removed. Snow will not blow away during the takeoff, and then, once it has become frozen to a wing surface, may be very difficult to remove. It can be swept off with a stiff broom, or brushed off with ropes thrown over the wings and snapped and sawed back and forth. This is best done by two men, but it can be managed by one man holding the rope behind the trailing edge of the wing. It is usually necessary to sweep the surface smooth afterwards, since the rope method does not achieve a smooth finish.

3. Ice can be removed by using just enough heat to loosen it. Too much heat will cause water to get into control surface bearings and freeze. Alcohol spray can be used as a last resort to remove obstinate snow or ice from localized areas. Frost on windows can be removed with alcohol, gasoline, copper or steel wool, but metal wool must not be used on plastics. Ice on prop devices and blades can be removed by direct application of heat; likewise for shock struts.

4. The wings and fuselage may accumulate a quantity of light blowing snow wherever openings remain uncovered. Inspect for such, in order to prevent takeoff with an overload of drifted snow. Condensation inside

wings and fuselage, as well as outside, will result from sharp changes from moderate to extreme cold. Careful inspection must be made to insure the freedom of all controls and mechanisms from such icing. Removal of this ice is difficult, and can generally be accomplished only by the application of heat, since chipping may cause damage.

5. The undercarriage may collect ice and snow; which may jam or prevent retraction of wheels, and hinder operation of locking devices. Loose snow also tends to blow into the engine nacelles on the takeoff, and then freeze on retraction so that it may be difficult or impossible to lower the undercarriage. A liberal application of anti-freezing oil will permit the ice to break off when power is applied to the hydraulic jacks.

6. Bomb bay doors and flap-operating gear may also lock through accumulation of ice or frozen snow, and should be treated in the same manner as the undercarriage components. These parts of pneumatic firing gear which are adjacent to the point at which the compressed air is discharged should be similarly treated.

7. Snow on the empennage may melt, run inside or over hinges and tabs and thereafter freeze. Clean it off. Inspect for ice all exposed hinges on flaps, elevators, ailerons, rudders, trim tabs, and bomb bay doors. Remove snow packed in the carburetor intake. Carburetor screens should be removed for snow operation. Clean antennae of snow and ice before takeoff.

8. Operate all ailerons, elevators, rudders, and all trim tabs through their complete travels, noting the force required. If excessive, investigate. This check also loosens grease, or reveals the use of wrong grease if seizure of controls has occurred. Trim tabs are important for safe operation, and since some incorporate a gear box filled with grease, the danger of frozen grease is obvious.

9. If the aircraft is to remain on Alert, heat, when available, should be applied to those portions of the craft where instruments, engine accessories, batteries, etc. are located.

10. Turrets should be checked before takeoff, and operated through the full range of traverse, elevation, and depression, in order to remove congealing fluid from remote parts of the mechanism and to maintain the temperature of the working parts. This will prevent sluggish operation, and in some extreme instances, the sticking of the turret. External power supply must be used for ground checks.

IV. MAINTENANCE CHECKS

It can be seen from the number of precautions listed above that eternal vigilance is the price of continued operation. Only if the routine of cold weather maintenance becomes habit and second nature to line men will the planes keep flying. Certain checks must become routine.

A. Sumps, Filters, Oil Lines

1. Drain all fuel and oil tank sumps, Y-drains, and filters before each flight. If no oil comes out of the Y-drain and oil tank sumps, the drains are probably clogged with ice or congealed oil; apply heat to thaw. The drain must be locked immediately after the water is drained, or as soon as oil flow occurs. Safetying is necessary for drains not of the self-locking type. Hydraulic filters should be drained at fairly frequent intervals.

2. Fuel and oil tanks should be filled to full capacity immediately after flight. If tanks require replenishment after oil dilution is accomplished, add additional oil and dilute.

3. Fuel, oil tank, and engine crank-case vents must be free of ice. Condensation may permit droplets of water to form in the vent line, where they freeze and cause stoppage; result, a collapsed or burst tank.

4. In general lines in which oil moves slowly require greater protection than those in which the flow is rapid; and lines directly exposed to the flow of cold air require greater care than those situated in the lee of the engine. Low pressure lines or those on the suction side of the pump require greater attention than high pressure lines, as the flow can be restricted by only a moderate congealing of the oil.

B. Struts and Other Hydraulic Units

1. Keep struts clean. This cannot be overemphasized. Immediately after dilution, wipe the shock strut piston tubes clean of all dirt, snow, and ice, using a rag soaked in the fluid used in the strut. Kerosene can be used to remove hard dirt and grit; then the piston must be relubricated with hydraulic fluid. Repeat the cleaning before takeoff. Ice and grit quickly cut and spoil shock absorber packing, especially at low temperature when it has lost much of its resilience.

After cleaning, keep the struts wrapped in clean dry rags until takeoff. Boots are now under development which may eliminate this wrapping, but these must be removed to check strut height.

In spite of precautions, leakage will occur and struts will deflate. Leakage is evidenced by fluid on the snow. Instructions on the plate fastened to the strut itself govern correct inflation.

2. Hydraulic Units, such as brake cups, fuel pump and accumulator diaphragms, pressure lines to brakes, etc. are likely to suffer increased leakage in arctic conditions, and the fluid level of the reservoir must be checked regularly to maintain proper level. Check hydraulic units through their whole range of operation. Probable causes of trouble are broken lines, ice in the lines, sheared hydraulic pumps, ruptured diaphragms, low air pressure in the accumulator, and sticking of selector and relief valves. If trouble continues, the fault may be in the type of packing used. Replace if necessary according to T.O. instructions for cold weather. The hydraulic fuse, which collects most of the moisture in the system, must be checked for ice; but ice also collects in other parts of the system.

Strut air valves frequently give trouble. If there is leakage, replace with high-pressure cores with seats which will give service at cold temperatures.

C. Control Surfaces

There are several hazards to fabric-covered control surfaces especially prevalent in the north. Running up the engines in deep snow and also taxiing through deep snow cause pieces of ice to be blown through the elevators. The removal and installation of wing covers frequently cause injury to control surfaces. Heat is necessary, in repairing tears in the surfaces, to prevent the dope from blushing, and thus preventing the patch from adhering. A shelter is therefore necessary, but hot air should not be blasted at the patched surface in order to dry the dope.

Never apply force to any fabric-covered control surface by leaning on it or gripping it in intense cold. Cracks or "ring worms" will develop on the hardened, dope-covered fabric.

D. Propellers

Propellers become nicked, and require sandpapering to keep them smooth. Aeroprops especially are subject to "wrinkling" after taxiing through deep snow. The pilot valve of the Hamilton Standard constant-speed governor may stick; the exterior of the electric head should be coated with airplane dope to prevent moisture from entering. In the Curtiss electric governor rusting of the rack and pinion gear may occur. Sticking and rusting are indicated by fluctuating RPM in flight. One remedy is to drill a hole in the head of the governor and to install a vent at right angles to the direction of flight, creating a constant vacuum inside the governor head. Propeller governors are a problem. Any congealed oil or condensation will cause unsatisfactory operation.

E. Anti-Icing and De-Icing Equipment

Make sure that the hose connections to the slinger rings are tight-fitting, and operate the prop anti-icing system. Check de-icing equipment during engine run-up when temperature is moderate or, in flight, when a warm layer is reached. All tanks for anti-icer fluid should be checked for proper level. De-icer boots are liable to tears and abrasions caused by wing covers, ladders, wear, etc. They should not be treated with de-icing oil. Sticking of the de-icer distributor valve may occur, rendering the de-icer boots inoperative. When coating prop blades with anti-icing fluid, take care not to get oil in the rubber fluid feed shoes. Propeller governors are critical, and are impeded by any congealed oil or condensation.

Two types of windshield wipers are in use at present, electric and hydraulic, and each has its own maintenance problems. The electric wiper must be checked for a sheared flexible drive shaft, while hydraulic wipers must be checked for sufficient fluid and pressure delivery. Both types of wiper should be checked with a wet windshield.

F. Electrical Equipment

Spark plugs, magnetos, harnesses, and leads are all subject to corrosion, caused by condensation. Inspection and cleaning are in order. At or below 23°F. (-50°C.), the aircraft battery should be removed if practicable, stowed and charged in room temperatures above freezing. Without such facilities, however, there is little object in removing the battery. Quick battery disconnects and accessible locations are currently being provided. Portable generators should be used when available to build up the battery. Whenever possible, use a battery cart to start an engine or to run electrical equipment. Do not operate electrically heated flying-suits, turrets, or other electrical devices unless a suitable generator is kept in operation.

The battery must be replaced if the specific gravity of the electrolyte falls below 1.240. The battery charge decreases proportionately with the temperature, and freezing results quickly when specific gravity is low.

G. Instruments

Below -31°F. (-35°C.), air driven flight and turn indicators may function sluggishly. Prior to takeoff, ground heaters should be used to bring the temperature of instruments to at least this level; and the level must be maintained in flight with cabin heat.

Condensate or moisture may collect in the manifold pressure gauge line and cause stoppage. Disconnect the gauge and force hot alcohol through the line to clear it.

Electric tachometer indicators may occasionally fail to operate immediately at the start of the engine, but become self-heating when the generator cuts in. Allow a five-to-fifteen-minute warmup period before condemning the instruments.

Directly connected oil pressure gauges should have diaphragms mounted in front of the firewall. The oil line from diaphragm to instrument should be filled with compass fluid. Autosyn transmitters should likewise be mounted forward of the firewall.

The plug valves of the instrument vacuum systems often become sticky at low temperatures. To ensure satisfactory operation, disassemble the valve without disconnecting the lines; clean the plug and the inside of the valve thoroughly, and apply a light film of low temperature grease.

Instrument field test sets utilize dry cells which have a very limited life (2-3 hours), especially when subjected to extreme cold, or when not in use with the battery switches off. Keep the instruments in a warm place and expose them to low temperatures for only short periods; or keep them well-wrapped in insulating material when exposed for long periods at a time, and not in use.

H. Tires

Approved snow and ice tires should be standard equipment for all craft operated in the arctic. One type of tire suitable for this purpose has metal inserts, called "bottle caps", molded into the tread. Another has lengths of coil springs molded into the tread. Tires and tubes must be mounted in a relatively warm place. Cactus proof tubes should not be used in the arctic. Tires must be properly inflated for the lowest operating temperatures anticipated, and with the full weight resting on the tire. Low temperatures harden rubber, and low pressure will cause the walls to crack and pinch. If tires are first inflated in a warm hangar they will lose pressure after standing in the cold. They lose about 15% of their pressure for every 60°F. drop of temperature.

Engine oil and hydraulic fluid cause rapid deterioration of rubber. Keep the tires clean. They should also be inspected for cuts or cracks due to contraction from the cold. Also, ice has a tendency to tear metal inserts from the tires during landing, if enough of these inserts are torn out, the tire becomes unsafe and must be replaced.

I. Miscellaneous

1. Various metals have different coefficients of expansion, and will therefore react differently to cold. It is necessary to make allowance for dissimilar contraction of control rods and cables.

2. Cleaning aircraft at -40° is best done by wiping with gasoline, then with a dry cloth. Gasoline is extremely dangerous on bare skin, freezing it instantly. Windows and windshields can best be cleaned with alcohol.

3. Lagging has been made ordinarily unnecessary by improved oil circulation, but long runs, particularly to coolers and reduction gear, may require lagging. This also refers to turbo-regulator balance lines, if not filled with hydraulic fluid. Electronic regulators are now being installed on multi-engined ships. A typical lagging consists of Lapok felt covering with waterproof and flame-resistant duck.

4. Tools and small parts may sink out of sight if laid down on the snow. Carry them in a belt kit, keep your box with you, or lay down some canvas or cowling on which to place tools and parts. In making emergency repairs, or replacing cold equipment, do not use too much tension in tightening nuts, bolts, cables, etc. They will expand on warming, and may either "freeze" tight or snap.

5. Solenoids may stick in cold weather, and must be tested. Other parts that must be checked regularly are boosters and fuel transfer motor; fuel shut-off valve; seating of dilution valve if the engine throws oil out the breathers, or if there is loss of oil pressure; exhaust collector rings and exhaust stacks, which may crack because of rapid engine cooling immediately after engine shut-down; tightness of engine oil outlet connections; shimmy damper, and antenna shock mount.

V. STARTING THE ENGINE

While starting the engine of an aircraft is, strictly speaking, an aspect of operation, there are difficulties and factors involved in cold weather starting which properly belong in a discussion of maintenance.

A. Preliminaries

Alway turn a cold engine three or four revolutions by hand before engaging the starter. If there is resistance to this hand turning, do not exert force, since you may strip an accessory gear. The start should not be attempted until the engine is thoroughly free and will spring easily when pulled up on compression. With a liquid-cooled engine, particular care is necessary. The coolant pump might be frozen. Turn very gently, and if there is any suspicion of tightness, apply heat and thaw out the pump.

It is important to turn an engine over by hand before starting in cold weather because the capacity of a battery is materially reduced. It delivers less current at low temperatures because of increased internal resistance. Always use external battery, if possible. Army fields are equipped with C-10 generator carts. Starting without an external power source is likely to damage the battery. For starting, the generator should show a charge of 26 to 28 volts.

B. Spark and Battery

To insure that an adequate spark is produced at the plug points, make certain that they are clean and dry. Proper use of the idle cut-off will reduce accumulation of condensed moisture and the possibility of ice formation on the points. The object of this procedure is to avoid leaving any products of combustion in the cylinders.

Spark plug fouling from condensation is to be expected if a cold engine fails to start readily. Partial firing expands moisture laden air, which quickly condenses, leaving small beads of ice on the spark plug electrodes. This ice increases with each unsuccessful start. After, at most, three or four unsuccessful attempts, you must remove at least one plug from each cylinder and heat to 65° or 75°C. (150° to 165°F.--comfortably warm in the hand) to dry the points. Replace and attempt to start immediately. If the engine can be made to fire on this minimum of one dry plug from each cylinder, the others will become dry enough to operate properly.

C. Primer Technique

Extended priming is required to assure successful engine starts in extremely cold weather. A light priming should be given before the starter is engaged and then, while the engine is being turned over, the primer should be operated with short sharp strokes until regularity of firing results. Do not prime an engine until you are actually ready to engage the starter.

Defective handling of the primer pump has frequently been a direct cause of the engine's failure to start. This is what happens: when a start is to be made, the pilot or crew chief will prime his engine, then proceed to

carry out a cockpit check, all the while discussing affairs in general with the other occupants of the aircraft. This delay permits the fuel to condense, flow down into the lower cylinder and fill up the combustion space, resulting in bent rods or broken pistons when the engine is turned over. Operate the primer, then, when you engage the starter, and operate it forcibly to insure that the fuel is at least partially atomized and sufficiently finely divided to burn satisfactorily.

When starting from cold, it may be necessary to keep the engine running with the primer before it will pick up on the jets. Anticipate this. Keep your primer operating until the engine is firing regularly. Remember, your first attempt at starting is your best.

An easier start may be obtained if a hot air blast is directed into the carburetor air intake while the starter is engaged. Warm-up is further facilitated if carburetor air is put on hot as soon as the engine is firing regularly. Apply heat slowly and only in the amount the engine will take without backfiring.

D. Regulating Oil in Starting

The engine should be started in the normal manner, without regard to the oil dilution system. After the engine is started, heaviness and high viscosity of the oil are indicated by high oil pressure, or by oil pressure that fluctuates or falls back when the engine RPM is increased. The viscosity of the oil can be decreased by pushing the dilution control momentarily several times. This procedure must be used with caution, because if the oil is too viscous, or stopped by ice so as not to flow, then supplying the engine pump with pure gasoline will cause an engine failure; the gasoline may cause the oil pressure gauge to indicate sufficient pressure, and give the impression that oil is flowing when actually it is not. Oil dilution after starting is suggested only if time and extreme temperature conditions do not permit engine warm-up in the normal manner.

If there is no oil pressure after the engine has been running for 30 seconds, or if oil pressure drops after a few minutes of ground operation, the cause may be: a. blown lines or oil coolers; b. congealed oil or ice in the Y-drain; c. ice in the oil tank sump drain: if no oil flows, heat must be applied and the water from the thawed ice drained; d. foreign material in the oil strainer, indicating that engine failure is the cause of low pressure. If the oil tank sump or Y-drain is frozen, or oil lines or coolers are blown, indications are that the pilot did not properly follow shut-down instructions.

Note: Cowl flaps must be kept open for all ground operations, and non-essential electrical units must be kept off until generator cuts in.

VI. OIL DILUTION

The oil-dilution system is essentially a method of reducing the viscosity of the oil in the engine and in the tank, so that the oil flows freely enough to permit the easy starting of the engine at low temperature. The procedure consists of diluting the oil with gasoline obtained from the fuel system. This is done immediately before the engine is stopped, when a cold start is anticipated later. Inasmuch as the high cranking torque of a cold

engine is due to the high viscous drag of the cold sluggish oil, particularly between the pistons and the cylinder walls, it is evident that a thinning of this oil before the engine is stopped will greatly reduce the cranking torque and make for an easy start.

Except for the installation of the hopper tank, oil dilution requires little change in any aircraft oiling system. A line is connected from the fuel pressure line to a special "Y" drain cock in which a spring-loaded poppet valve is installed. This valve is operated manually from the cockpit, and before the engine is stopped in cold weather, a small amount of fuel is allowed to enter the oil-in line at this point by holding the dilution control open for a short time while the engine is operating. This permits the diluted oil to replace the heavy oil throughout the entire engine. The thinner oil facilitates starting in the cold later. Some of the diluted oil is returned to the hopper in the supply tank during the last minutes of operation; this diluted oil will be the first oil to come into use at the next start, insuring a positive flow to the engine pump.

A. Operation of the System

Certain modifications of established techniques, and certain new techniques must be learned to insure proper dilution:

1. Technique: Before stopping the engine, when a cold weather start is anticipated, hold the oil dilution control in the "ON" position for the proper period of time, depending on probable air temperatures. When the oil temperature is above 50°C. (122°F.), oil dilution is not very effective, since fuel vaporizes at 70°C. (158°F.) and above. Furthermore, gas fumes from engine breathers are a serious fire hazard. If oil dilution is intended, and engine oil temperatures are too high, stop the engine and let the oil cool to below 40°C. (104°F.), then restart the engine and dilute. During sub-zero temperature, where a long dilution period is required, the engine oil may go above the maximum 50°C. desirable. It may then be necessary to break up the dilution process into two or more short periods. This interruption works neither advantage nor detriment to the procedure. If the oil tank needs servicing, the dilution process must be divided, part to be accomplished before, part after the oil tank is serviced. After dilution is accomplished, shut off the engine in the normal manner (except those engines which must be stopped by shutting off the fuel to prevent after-firing), but continue to hold the dilution valve "ON" until the engine stops. With an engine which must be stopped by shutting off the fuel, stop the engine first and allow it to cool, then start it and dilute the oil. After dilution, stop the engine by shutting off the switch, holding the valve "ON" until the engine stops.

Note: Insufficient oil dilution results in broken oil lines and blown-out oil cooler cores, as well as difficult starts and possible engine failures due to poor lubrication.

2. Figures: The tables below indicate (a.) the per cent of dilution by volume required to provide similar oil viscosities at each temperature given; and (b.) the amount of time needed for proper dilution at various temperatures:

(Grade 1100 oil)

(a.) Air Temperature	(4°C) 40°F	(-12°C) 10°F	(-29°C) -20°F	(-46°C) -51°F	(-54°C) -65°F
Per cent dilution	0	10%	20%	30%	35%

(b.) At each of the following temperatures, the dilution switch is held on for the proper number of minutes, then the engine is stopped, and the switch released:

Anticipated ground temperature:	4° to -12°C (40° to 10°F)	-12° to -29°C (10° to -20°F)	-29° to -46°C (-20° to -51°F)
Hold switch "ON"	3 min.	6 min.	9 min.

For anticipated ground temperatures below -46°C., add one minute to the indicated time for each 5°C. (9°F.) interval. Deviations from these dilution periods, if found to give satisfactory results, are authorized.

B. Precautions

Oil temperature must be maintained below 50°C. while diluting. If oil temperature continues to rise with the oil cooler shutters open, close the shutters, since the oil in the cooler may have congealed. Dilute at idling speed (1000-2000 RPM). Avoid spark plug fouling. A short acceleration period of 10 seconds at the end of a dilution run is usually satisfactory to clear spark plugs. Under all conditions release the dilution switch only after the engine stops.

Engine oil pressure must not be permitted to fall below 15 pounds per square inch. If necessary, stop engine, wait 15 minutes, and continue dilution. Operation of the dilution system is indicated by a substantial fuel pressure drop. If this drop is not obtained, investigate; the dilution solenoid may be stuck, the line plugged, etc.

On all airplanes equipped with Hamilton Standard hydromatic propellers, depress the propeller feathering button for a 2 to 4 second interval, or a maximum change of 400 RPM, and pull out. Do this near the end of a complete dilution minute. Repeat three times. This will displace the undiluted oil from the feathering lines which would otherwise congeal and prevent feathering; it also provides diluted oil from the hopper so that emergency feathering can be accomplished under extremely cold conditions. (Note: A slight amount of oil leakage through the blade packings is to be expected.)

Caution: Oil dilution as described above is not applicable to the V-1650 engine, which will not scavenge satisfactorily with diluted oil. If oil dilution is used, the engine will be warmed up normally and tested at high RPM for 90 seconds to determine that loss of oil through the breathers will not occur. If oil discharge is noted, continue warm-up to evaporate the fuel in the oil system. If oil is expelled from the engine breathers during ground run-ups, check oil level in tank prior to release for takeoff. These precautions are necessary to avoid loss of oil in flight.

C. Other Considerations

1. Turbosupercharger Regulators. During dilution, turbosupercharger regulators operating on engine oil should be operated in order to expel all undiluted oil from the piston chambers. During the last two minutes of the last dilution period the regulator control should be repeatedly operated from low to high boost position, this to be accomplished in a minimum period of 8 seconds.

2. Dilution Controller. Some aircraft are equipped with an automatic oil dilution controller switch in the cockpit. This device is designed to close the dilution valve when the dilution in the oil system reaches a preset percentage. The procedure: Set the desired dilution percentage on control unit, operating engine at 1000 to 1400 RPM using lowest RPM which will maintain 25 PSI or more oil pressure. The dilution switch is then turned on "Automatic". Fuel pressure will noticeably drop or a lamp will light to indicate dilution is taking place. When the desired dilution is reached, the control shuts off automatically. A placard in the cockpit bears instructions. If the controller does not function, dilute manually in the method already described.

3. Oil Scavenging System. Oil dilution may have an adverse effect on an engine oil scavenging arrangement which is inadequate or critical. The term "overdilution" is used to indicate any amount of dilution which causes the engine scavenging system to break down and discharge oil through the engine breathers. This condition may result in the complete loss of all engine oil in a short period. If the outlined procedure is exercised with care and judgment, these difficulties will not normally occur. High percentages of dilution have no serious effect on engine bearings if the oil temperatures remain normal. If oil discharge occurs at low temperature, it can be stopped by reducing power and RPM immediately. Satisfactory dilution should be based on experience with similar conditions of engines and anticipated weather temperatures. Once the oil has been diluted, it should not be fully diluted again until after 30 minutes of operating time with oil temperature above 50°C., the conditions necessary for complete vaporization of the fuel in the oil. If a short ground run-up is made, and the plane not flown, then some dilution is necessary to replace the fuel vaporized in the run-up. The time of dilution required is in a simple proportion: Time in minutes of ground run is to 30 minutes as time of redilution required is to full dilution. If the run-up at above 50°C. took 10 minutes, redilute one-third. The dilution period at shut-down should in no case be less than 30 seconds.

On planes which have unsatisfactory scavenging systems, it may be necessary to ground run the engines to boil the gasoline out of the diluted engine oil before takeoff in order to avoid loss of engine oil in flight. Ordinarily, the procedure is to operate an aircraft engine at normal operating temperatures for about one half hour to permit the fuel in the oil supply to evaporate and cause the oil to resume its normal viscosity. High temperatures will reduce this time slightly. If necessary, immediate takeoff may be made after oil dilution without the normal warm-up, provided there has been a rise in oil temperature and the oil pressure is steady.

4. Oil Pressure. If an engine equipped for oil dilution suddenly shows a loss in oil pressure, or throws oil out of the breather during flight,

check it upon landing to insure that the oil dilution valve is in the "closed" position and fully seated. An electrically operated valve should be momentarily turned "ON" and "OFF" in an attempt to complete the seating of the valve. The fuel pressure gauge should drop when the switch is on. If dilution causes a loss of oil pressure, satisfactory operation will be resumed when the viscosity of the oil is restored by running the engine and evaporating the gasoline in the oil.

VII. IMMERSION HEATERS

Normally, immersion heaters are unnecessary for starting and need not be used unless difficulty is encountered with oil dilution. Oil tanks are provided, however, with receptacles to permit the use of 110-volt AC immersion heaters, which are electrical resistance elements encased in a tube supplied with energy from an outside power source. Under no circumstances should the heater be connected with the airplane battery. If used, it should be connected to a C-10 battery cart, or generator.

The oil level in the tank should be checked to insure that the heater is entirely submerged. Immersion heaters should always be installed before the oil has cooled, and should not be relied upon to thaw congealed oil; such oil does not circulate, and will carbonize about the heater, and burn.

All immersion heaters require a 110-volt power source. Two sizes have been standardized, 250 watt and 750 watt. Use the 250 watt size in self-sealing tanks. Oil immersion heaters are being made ground equipment as rapidly as possible. (Certain types of planes will retain the heater permanently installed until altered to accommodate the filler neck type.) Immersion heaters are inserted through the oil filler cap and plugged into the power source. They are removed just prior to starting, and must be thoroughly cleaned to prevent adhesion of particles, which will contaminate the oil when the heater is next used.

Continual operation is not necessary. Two-to-four-hour periods of operation, with similar off periods, will be sufficient to keep the oil in the tank fluid. Note: Type L-2 oil servicing trucks will have a gasoline-burning oil heater installed beneath the oil tank in order to provide hot oil for servicing aircraft. -- T.O. #00-60-3

VIII. EXTERNAL HEAT

While oil dilution and immersion heaters play an important part in cold weather starting, they must be supplemented below -20°F. with external heat. And it is desirable that such external heat be applied at zero C. (32°F.) or below. With a combination of external heat and either oil dilution or immersion heat, successful starts have been made in -65°F. temperatures.

A. Types of Heaters

A number of standard heaters are available, all of which burn a fuel-air mixture. The resultant hot gases are directed to an oven surrounded by copper fins which radiate heat. Air is then passed across these hot fins, becomes heated, and is directed against the part to be heated. There are three general classifications: spot heaters, space heaters, and pre-heaters.

Spot heaters are small compact units, chiefly used to heat only a particular localized object or spot, such as armament, instruments, windshields personnel, etc. Space heaters are larger and produce much more heat. They are provided with a duct system which carries the heated air to several different outlets. Preheaters are independent units having their own engine, blower, fan, heat exchanger, duct system, and fuel tank. They may be moved to the place where heat is desired. This type is designed for any kind of heating job, but its chief use is to preheat aircraft engines and accessories. Another, hand-operated preheater, called the Hand Crank, is used to preheat the engine of the large preheater, to heat batteries, wheels, and parts where a quick application of heat is needed. Note: Type L-2 oil trucks will have a gasoline-burning oil heater installed for servicing hot oil to aircraft.

There are two types of ground preheaters used by the AAF, the Type D-1 and the Type F-1. The D-1 weighs 183 pounds, with a capacity of 80,000 BTU per hour, and an eight-hour supply gasoline tank. It is mounted on retractable wheels, and has auxiliary sledge runners. At temperatures down to -29°C. (-20°F.) one Type D-1 heater will keep two engines warm; at -40°C (-40°F.) or lower, one D-1 heater is required for each engine.

The F-1 Heater is a large mobile ground type with a capacity of 250,000 BTU per hour. Although both heaters may be used for the same purpose, the Type D-1 is preferred for aircraft engines because of its higher heat rise at the duct outlet, its lighter weight, and greater mobility. On the other hand, the Type F-1 with its greater volume of heated air, is preferable for the heating of portable maintenance shelters, temporary buildings, or the interiors of aircraft.

The hand-operated heater has a two-hour gasoline supply tank, weighs 10 pounds, is ignited manually, and has an output of 25,000 BTC per hour. It is useful for quick warming of small mechanisms. At -29°C. (-20°F.) 100 octane gasoline is necessary for it. This heater should not be used to heat shelters or occupied enclosures, since the heated air it delivers is not free from carbon monoxide.

B. Conditions for Use of Heaters

Heaters must be kept sheltered and warm if they are to function when needed. As a last resort the hand-crank heater, or even open-flame fire pots used with care and ingenuity, may be used to preheat both Type D-1 and Type F-1. Two standard methods of keeping the heaters warm are now in development. One involves the use of a small shelter in which the heating units and their power units are kept, the heat for the shelter being provided by an Evans Stand-by heater. The other method utilizes a sledge on skis having an insulated cover, and also warmed by a Stand-by heater; this sledge will hold a Type D-1 engine preheater and a Type C-13 auxiliary power plant.

When neither of these methods is available, the heaters may be kept warm by covering a number of them with a large tarpaulin fastened down to the ground at the edges, and then inserting the ducts of Stand-by heaters under the tarpaulin. The number of heaters necessary depends on the severity of the weather.

Heat should be applied to engines, accessories, cabin and turrets. Each large preheater has three ducts, and can heat several points simultaneously. A cowl door is situated in each engine so that sufficient heat is available to the accessories section; the instrument panel in the cockpit must also receive heat. In extremely low temperatures it may be necessary to direct the three ducts of a heater into one engine cover: at the forward lower section of the cowling, at the oil cooler, at the accessory section.

Heat should be applied to both the front end of the engine and to the accessory section until cylinder head temperatures reach 20°C..(68°F.). (Standard engine covers of 7.9 ounce duck are provided with sleeves for attachment of heater hoses at the important points; correct covers, or tight-fighting makeshifts are essential for proper engine heating.) If sufficient heat is not available to warm the entire engine, concentrate on the rear accessory section, with second priority on the nose gearing and propeller hub.

Caution: Do not permit hot air from heaters to blast against ignition harness, flexible hose, self-sealing tanks, or other rubberized or fabric materials unless the hand can be held without discomfort for at least one minute on the part. Do not apply heat directly to oil tanks having self-sealing liners since these liners will melt and cause the failure of the oil system. Because of the insulating qualities of such tanks, several days of above-freezing temperature are necessary to loosen congealed oil in the system.

Below -21°C. (-6°F.) heat should be directed at the instrument section. If the craft is to be kept on alert, heat must be applied to bomb sights and AFCE batteries; a temperature of 2°C. (36°F.) is necessary to insure immediate operation.

IX. EMERGENCY PROCEDURES

A. Continuous Operation

In extreme cold, without adequate heating facilities on hand to assure engine starting, it may be necessary to keep the engines running throughout the lay-over period. This is practicable, of course, only if fuel is sufficient for the necessary time of ground running at 1000 RPM, and for flight to the next source of fuel. A crew member will have to remain on watch while the engine is running. Occasional running up to 1500 RPM is necessary to clear the engine, and oil pressure should be maintained at normal even though it is necessary to operate the oil dilution periodically to reduce oil pressure.

B. Draining Oil

This should not be necessary when the proper dilution procedure has been accomplished, except when it will be expected that ground heating facilities will not be available at starting, and that temperatures will be below -20°C. (-4°F.). Ground heating equipment and auxiliary power supply should be available where needed. With these two facilities and proper dilution, starts have been made in outside air temperatures as low as -65°F. When outside heat will not be available for starting, or when dilution cannot be accomplished, all the oil must be drained into clean containers and stored in a shelter above freezing. Where warm storage is not available, the drained oil must be heated on a stove or a flame pot until it flows freely, and then it must be poured into the oil tank immediately before starting the engine. The best temperature for the oil is 70° or 80°C. (158°-176°F.)

C. Starting without Oil Heating

In extreme emergencies when it is known that containers and heating facilities are not available, the following procedure is sometimes successful if the temperature does not fall below -30°C. (-22°F.):

1. Use normal oil dilution procedure before stopping engine.
2. After shutdown, drain sufficient oil from the system to bring the oil level to two-thirds of its total capacity.
3. Restart the engine and run with covers over cooler if necessary, until oil temperature shows 50° to 60°C. (122° -140°F.).
4. With engine still running at 800-1000 RPM, slowly add enough gasoline at the oil filler neck to fill the system. This gives a 2:1 ratio of oil to fuel and will produce some dilution of the oil adjacent to the tank hopper.
5. Restart after 20-30 minutes and give a second dilution, using only the normal dilution procedure, followed by final shutdown.

Caution: This is strictly an emergency procedure to be used only when immersion heaters are not available and when equipment is lacking for draining and warming oil. Also, when the fuel evaporates, only two-thirds of the total oil capacity remains in the system; this must be sufficient for the flying that will be necessary to reach a new oil supply.

X. COOLANT

If proper glycol mixture is maintained, and particularly if ground heaters are utilized for starting, draining should never be necessary. If it becomes necessary, however, and if heating facilities and clean containers are available, the coolant fluid may be drained, warmed, and replaced in the system just prior to starting the engine. Warm coolant materially assists in starting. The coolant should not be drained until its temperature drops to 5° or 10°C. (41° or 50°F.) in order to avoid sudden chilling of engine parts. Always leave drain cocks open until just before the heated coolant is returned to the system.

XI. LAY-OVER INSTRUCTIONS

When extreme cold makes an aircraft lay-over necessary, the normal oil dilution procedure may be revised to provide additional fluidity and safety. If the engine has been started and diluted several times during a lay-over of several days, it should be ground-run for at least one half hour at normal temperatures, prior to takeoff. Also, check the oil level, which may have fallen considerably because of the evaporation of the gasoline used in dilution. This warm-up and check will help eliminate any excessive dilution which might cause oil discharge through the breathers, or loss in oil pressure during high power take-off or operation.

In extreme cold, when the airplane must be kept on the alert without adequate heating facilities to assure engine starting, it may be necessary to run the engines periodically through the lay-over period. The cylinder head temperature should be kept above zero C. (32°F.).

For long lay-overs, the battery should be removed and stored in a warm place, and the oil and coolant systems may be drained. If, during the lay-over, the temperature rises above freezing (32°F.), drain all fuel systems and oil tank drains of condensate immediately, before the temperature drops and the condensed water freezes.

PART II--ARCTIC OPERATIONS

I. PREFLIGHT

Operations in the North require considerably more preflight preparation than is necessary elsewhere. The relative importance of this part of flying technique cannot be overstressed. A mission may fail disastrously because of improper attention before the plane leaves the ground.

Many of the precautions outlined in the section on maintenance apply equally to air crews and to ground crews. These involve personal care and maintenance checks, including removal of frost, ice, and snow.

A. Personal Precautions

Remember the effect of cold metal on your skin. You will wear gloves, of course, but just to make sure, wrap tape, cord, or cloth muffs around control sticks or wheels, throat or hand mikes, and any other parts you might have to touch.

Neglect of emergency equipment has caused death or misery to many flyers forced down in arctic wastes. Nowhere is survival equipment so important. Your plane should carry as much as possible of rations, extra clothing, sleeping bags, and heating equipment. This equipment should be checked before every trip.

A personal precaution that requires cooperation is the care to be taken about running up engines to windward of other planes, personnel, or ground installations. Prop wash can cause quick frostbite, and a blast of snow or moisture-laden air can undo hours of maintenance work on other planes.

B. Frost and Snow

Even a very thin layer of hoarfrost an eighth of an inch thick will alter takeoff characteristics. Loose snow will not blow off during takeoff and may result in refusal of the ship to leave the ground until a dangerously high speed has been reached; or worse still, in a stall during the initial climb. Remember, the thinnest film of ice forms a base upon which more ice can and will rapidly form.

Frost will usually form on the windows either while the engine is heating, or when the crew enters the machine. This should be removed with alcohol, copper, or steel wool. Light mist forming on the windows will usually disappear when circulation is established.

C. Checking Up

When the plane is in the air it is too late to test instruments and controls. An obvious and vital part of preflight technique is to check all main and auxiliary control hinges and surfaces to find particles of ice or hard snow that might cause jams. Check all controls to insure free and easy movements, and operation to full travel without blockage. Another job is to check the pitot heat on, and to make certain that heat is available for the wind shield.

In all of these operations the air crew should be on hand well in advance, in order to cooperate with the ground crew and to advise and assist preflight preparation.

II. TAXIING

Some of the precautions that must be taken on the desert apply also to taxiing in snow. The same general warning applies against running up engines or taxiing to windward of other planes or personnel.

When taxiing in loose snow, hold stick or wheel well back, and keep momentum. Avoid abrupt turns, but if you must make them, use a minimum of differential braking; otherwise the wheel will pivot and dig in. Tricycle gear equipment is particularly difficult to taxi in loose snow. The nose wheel has less tendency to trail properly as the depth of the tire-sink increases. The smaller diameter of the nose wheel can cause it to dig in even while the main wheels move freely. Thus the nose wheel in deep snow takes the full thrust of the engines. Raising the elevators will relieve the pressure. Thoughtless gunning will result in the caving of the nose strut. A strut thus abused, even if it does not collapse, will be out of round at the packing gland, causing leaky packings. Damage can also occur to props and engines, if the props come down far enough to hit their tips on the snow.

If you must stop, select a relatively hard standing. If no hard standing is available, taxi in a circle and stop in your tracks.

Apply sufficient brake while taxiing to generate enough frictional heat to dissipate any ice or moisture. Use sufficient engine power to require use of brakes. This will serve two purposes: to dry your brakes, and to maintain engine temperature.

Obstacles may be hidden by fresh-fallen snow. Watch out. If frosting is severe, the plane can be kept free by taxiing to the takeoff with frost covers in place. Do not operate electrically heated units which are not absolutely required, until the generators cut in. Storage batteries have little strength at sub-zero temperatures, and any attempt to use them may ruin the battery or electrical system.

III. THE TAKEOFF

Three main difficulties must be mastered in taking a plane off the ground in arctic conditions. Any one of these can be disastrous to the inexperienced or unprepared pilot.

A. Vision

Despite all the precautions taken by ground crew and air crew during maintenance and pre-flight periods, there can still be windshield icing or frost formation if ground haze is present during the actual take-off. The pilot must be prepared for this, and be able to handle his craft during the time it takes for the windshield to clear up.

On newly formed snow, or on a dull day, shadows are not visible. An effect somewhat similar to that of glassy water will prevail, and it will be impossible to judge height after leaving the ground. Pilots who thought themselves at a safe height of hundreds of feet found their planes plowing into the snow, or dragging a wing and wrecking the craft. This phenomenon requires the use, if possible, of some reference point or substitute for a horizon. Such reference points can be far to the side--trees at a distance, familiar knolls, hills, river banks. Any object, the size and characteristics of which are known, will indicate the approximate surface, although the runway ahead may be entirely blended in milky mist. Avoid staring ahead when there is nothing to focus on. In any event, the pilot should be prepared for instrument takeoff procedure, or to go on instruments, since instrument weather can develop at any time.

B. The Takeoff Run

In taking off heavily loaded aircraft from snow the run can be shortened by using the lift as early as possible to reduce the weight on the undercarriage and thereby cut down ground friction. It is a matter of depressing the tail slightly after "stepping" until the best planing position is found. This position is indicated by an increased rate of acceleration, and can be easily sensed.

On snow an optimum running attitude can generally be found for each set of conditions, and this will usually be with the tail somewhat lower than for normal takeoff on a hard surface. When snow is rough or sticky it may be desirable to pull the plane off with the tail well down, and then to pick up flying speed, holding the plane a foot or so off the ground. In heavily drifted snow, the pulled takeoff is practically essential in order to avoid damage. The aircraft will usually be thrown into the air, and just before it settles back the tail should be brought down as far as possible without stalling, and the craft held in the air if speed is sufficient.

These procedures do not apply if emergency makes necessary a takeoff with frost or snow still on the wings. Under these conditions, the craft should be allowed to fly off in flying position, and on no account pulled off the ground or climbed steeply. The possibility of stall with iced wings has been made clear, and this stall is abrupt and dangerous. Takeoff should be attempted with snow or ice on wings only when there is no choice.

After takeoff from a field covered with snow or slush, the landing gear, flaps and bomb-bay doors should be operated through two or three complete cycles, to loosen ice and prevent freezing in the "up" position.

C. Carburetor Ice

A potent source of trouble at takeoff and immediately afterward is carburetor ice. A thorough takeoff check and intelligent procedure at this point will minimize the possibility of such ice forming just after the plane has become airborne. The trouble is most frequently encountered during conditions of high humidity such as prevail during a fall of wet snow. High moisture content, incidentally, is indicated by large snow flakes; in cold dry air, the snow forms in small hard particles.

Idling or taxiing with partial power at low temperature will allow the engine and carburetor heating devices to cool. A sudden attempt to take full power from the engine will simply result in coughing and spitting and may contribute to carburetor icing just after takeoff.

The engine should be thoroughly warm, and opened to full power gradually. The initial rush of air through the carburetor when takeoff power is applied results in the rapid lowering of carburetor temperature before either the exhaust or oil heat have time to build up.

Ice under these conditions usually occurs within 30 seconds after the takeoff run starts. When it is suspected that atmospheric conditions make icing likely, the pilot should be careful not only to warm the engine thoroughly, but also to get heat on the carburetor before takeoff and thus prevent ice formation, and assure that all ice is eliminated from the induction system. Then, immediately after takeoff, when power can be reduced, carburetor heat can be adjusted to maintain recommended temperatures. Carburetor heat should not ordinarily be used during takeoff, because of the definite power loss. A compromise may be necessary: if the heat is not applied, there is the risk of icing. Relevant factors are: degree of icing anticipated, length and condition of runway, loading of the aircraft.

If the plane takes off, and then icing develops, the pilot must endeavor to remove the ice by means which will be suggested later, bearing in mind that sufficient power to maintain flight until a suitable landing is possible can often be obtained by running on a lean mixture.

IV. FLIGHT

Many of the natural hazards continue to cause difficulty after the plane leaves the ground. Visibility continues a problem with a low-lying sun and mist; carburetor ice may form during certain atmospheric conditions, and ice may form unexpectedly on the wings and control surfaces. The pilot must be extremely sensitive to his instruments, to catch any hint they may give of danger.

A. Visibility

A low midwinter sun in northern latitudes will not dissipate fog or low cloud. Layers of thin mist may start at 100 feet, and may remain during the day. This mist is generally quite thin and does not interfere with vertical visibility, although horizontal visibility is poor. The formation of ice or frost is good above mist or ground drift, although, as frequently

in arctic flying, surface detail is obscured. Ground haze, or "fog", often hovers over airfields during low temperature weather, and also over towns or any cluster of houses. This smoke haze may cause overflying the settlement in calm weather.

With high winds and low temperatures, fine drifting snow will frequently be encountered up to a height of 50-300 feet. This snow is ground drift and from above appears very much like uniform light fog. Vertical visibility generally remains good, but during landing and takeoff, horizontal visibility will be poor, and the pilot coming down for a landing should expect a change for the worse.

Mist or ground drift will often create a false horizon. A constant instrument check in flight attitude is therefore essential. The seat of the pants is notoriously deceptive in arctic flying.

B. Carburetor Ice

You will not see, hear, or feel carburetor ice forming until it is too late. Watch your instruments. They will enable you to detect icing conditions. And remember, your carburetor can ice with the free air temperature as high as 95°F. (35°C.).

1. Conditions, Prevention, Indications

Conditions that permit icing of the induction system are clouds, rain, fog, sleet, wet snow, supersaturated vapor, and high relative humidity. This ice may be of two kinds: a. atmospheric ice formed from water which originally existed in the atmosphere as snow, sleet, or supercooled moisture, including ice formed by liquid water hitting surfaces that are colder than 32°F.; and b. fuel evaporation ice formed by the cooling effect of the evaporation of the fuel after it has been introduced into the carburetor air stream. If the moisture content of the air is high, this type of ice can form, and has been known to form with free-air temperature up to 95°F. Icing is most likely to occur when the carburetor air is between -5°C. and 15°C. (23°F. to 59°F.). Try to maintain carburetor air temperature between 15°C. and 40°C.

Do not wait for engine troubles to warn you of ice formation. Prevent it by using whatever carburetor heat is necessary, as indicated by conditions. Air intake ramming conditions may require use of the control nearly full on at first, to get adequate heat. Once this initial effect is noted, however, a small movement of the heater control will cause a large range of temperature changes. It is good practice to apply carburetor heat for one to two minutes every half hour during flight, and likewise, to increase prop speed about 200 RPM to assure governing at extremely low temperatures (return to cruising RPM as soon as the tachometer indicates that the cycle is completed). When flying with mixture control in "Cruising Lean", apply sufficient heat to maintain carburetor air temperature below -5°C. or above 15°C. When cruising under severe icing conditions, use at least 75% engine power, with the mixture on rich side of best power. Apply carburetor heat to effect full vaporization. Carburetor air temperature of above 40°C. (104°F.) may cause the engine to detonate; therefore apply heat only until the engine operates smoothly. If icing is expected, move the throttle frequently to prevent freezing in one position (throttle ice).

Develop consciousness of moisture in the air. Check for moisture by applying heat; then note the effect in the operation of the engine. When applying carburetor heat under icing conditions, with precipitation near the freezing range, use full carburetor heat to make sure that any ice is eliminated; then maintain recommended temperatures.

Normally the formation of ice in the induction system can be detected by a gradual loss of RPM with a fixed pitch propeller. Another sign is a gradual loss of manifold pressure, not caused by change in throttle position or in attitude of flight. It is possible that a pilot off guard, assuming throttle creep, will keep advancing his throttle gradually to maintain constant RPM or manifold pressure without realizing that carburetor ice is forming. Rare, local conditions may change these indications somewhat, so be on the alert. Under extreme conditions, ice may form so rapidly as to cause abrupt power loss. Aircraft equipped with automatic boost control will not provide warning by loss of manifold pressure until icing becomes serious.

Where icing has progressed, the air intake channel is considerably reduced in section. Thus the quantity of air entering the engine is reduced and the mixture becomes rich. Your fuel-air analyzer will indicate this condition. If your mixture becomes rich for no apparent reason, or if the manifold pressure or RPM with a fixed pitch propeller begins to drop, then it is time to put carburetor heat full on. There will be a slight loss of power when heat is applied. If the manifold pressure, or RPM, continues to drop--change to rich mixture.

2. Technique

Do not advance throttle while cruising until the effect of full heat applied to the carburetor is achieved. Act quickly. Ice accumulation is progressive and you may have only a minute or two in which to stop it.

Turning on carburetor heat causes a slight loss of power, indicated by a drop in manifold pressure due to reduced air-intake pressure and the lower density of the warm air. This loss of power involves no sacrifice in engine efficiency when operating with the carburetor mixture control in the automatic position, since an increase in carburetor air temperature does not enrich the mixture. On the other hand, under manual mixture control, any increase in carburetor air temperature will enrich the mixture; it will then be necessary to readjust the manual control whenever the carburetor heater control setting is changed.

Carburetor heat should not ordinarily be used during takeoff. Under icing conditions, carburetor heat should be used immediately before takeoff, to insure that all ice is removed from the induction system. Then, immediately after takeoff, when power is reduced, carburetor heat should be adjusted to maintain the recommended temperatures when icing conditions are indicated.

The carburetor heat control should be in the "hot" position when in a long glide before landing, but should be in the "cold" position immediately prior to the landing approach in order to have full power available.

3. Emergencies

As a last resort: Turn on the alcohol de-icing pump if the plane is equipped with one; or put the carburetor heat on full cold and lean the mixture until backfiring occurs. The backfire will loosen the ice and blow it clear of the intake passages. Ice can sometimes be dislodged by closing the throttle. But both these procedures are hard on the engine and carburetor mechanism, and should be used only in extreme emergencies.

On craft equipped with alcohol carburetor de-icing systems, the following additional operational instructions must be followed: When icing conditions are indicated, the alcohol pump should be turned on immediately before the take-off and the carburetor heat control should be placed in the full cold position. The richer carburetor mixture caused by the alcohol will result in a slight loss in engine power. When a safe altitude has been reached, the carburetor air heater should be adjusted as outlined above, and the alcohol pump turned off. Except in emergencies, the alcohol system should not be used in flight. When you do use the alcohol system, remember that the alcohol supply is limited to about one hour of continuous use. Attempts should be made periodically to adjust the carburetor temperature. Warning: The use of the alcohol de-icing system at a very low power and low engine idling speeds produces a rich mixture which may choke the engine.

Possibly the simplest advice is to fly the ship to a more favorable altitude, or an area where precipitation can be avoided, and where the temperature is safe. Simply leaving a cloud bank, or climbing above fog may arrest ice formation by avoiding atmospheric humidity.

C. Ice on Surfaces

Icing of wings, tail surfaces, and propellers is likely to occur under the following conditions: visible moisture in the form of precipitation or a cloud; air or airplane surface temperatures of less than 36°F. The heaviest icing of wings, fuselage, and propeller usually occurs in the range between 15 and 32 degrees F. However, ice can form at any temperature below freezing, and has been known to form at temperatures as high as 40°F.

1. Conditions of Icing

Icing is likely to occur:

a. below a temperature inversion. This typical situation along a polar front is caused by the relatively warm air mass rising above subfreezing polar air; moisture falling from the upper warm air through the lower cold air is cooled to sleet, freezing rain, or snow, and usually forms clear ice. This condition can be avoided by climbing into the warmer air.

b. along fronts; in warm fronts, the overrunning warm air may be above freezing in the lower levels and thus prevent icing in that region. The upper portion of the cloud system, however, may be cold enough to cause severe icing. Stay in the lower levels. In cold fronts, the presence of cumuliform clouds and the upward air movements that cause them are likely to cause clear ice formation. Although the cold front formation is narrower than the warm front, icing is more severe because of the higher rate of accumulation.

c. over mountains; icing is most likely to be encountered and is most dangerous here. Mountain ranges cause upward motion of air capable of supporting large droplets of moisture. With low temperatures, clear ice results. The most severe icing will be encountered above the crest and to the windward side. Avoid turbulent areas. When you run into wet, sticky snow, climb above it where temperatures are colder, and the snow will not adhere so readily. Fly through an icing area fast.

2. Kinds and Effects

Depending on conditions, ice may take any one of three forms: clear ice, or glaze; rime; or frost; or it might be a combination of the three.

Clear ice or glaze is a hard dense ice which forms when the plane is flying through clouds consisting of large moisture droplets, or through a freezing rain. Clear ice is the most dangerous form. It builds out from the leading edges in a mushroom shape that spoils the airfoil and therefore decreases lift.

Rime is an opaque, whitish ice with a granular texture, formed by small droplets of water. Rime ice does not destroy the shape of the airfoil, and can be removed easily from leading edges with pneumatic de-icing boots. Rime, however, does have a tendency to stick just to the rear of the boot. Being rough, rime increases the drag and increases the stalling speed of airplanes with high wing loading.

Frost consists of small separate ice crystals. Although not particularly dangerous during flight, it can be dangerous in a takeoff and must be removed from wings and tail surfaces before takeoff. Under severe frosting conditions, it may be necessary to keep frost covers in place while taxiing, and even up to the moment of takeoff. And watch for frost formation during takeoff.

The effects of icing may be summarized as follows:

a. Decrease in lift due to change in wing section.

b. Increase in drag due to rough surface, and increase in stall speed.

c. Decrease in prop efficiency due to alteration of the blade profile and increased blade thickness.

d. Vibration due to unbalanced prop if ice is thrown off irregularly.

e. Loss of control due to prevention of movement of control surfaces.

f. Increased wing loading due to weight of ice.

g. Loss of inherent stability due to displacement of the center of gravity caused by the weight of the ice.

h. Improper functioning of air speed indicators, flight indicators, and other gyro instruments that are venturi operated, as a result of icing of the venturi throats and pitot tubes.

The remedy: Turn on wing and tail de-icers, attempt to escape from icing conditions. Warning: Never land with de-icers on; they will act as spoilers, and seriously disturb airflow over the wing.

3. Propeller, Pitot, Windshield

Propeller icing may occur in any condition in which wings and control surfaces will ice. Such ice is especially dangerous, since it decreases propeller efficiency and creates an out-of-balance condition and excessive vibration.

If flying must go on under icing conditions, formation on propellers, blades, and spinners may be prevented by anti-icing solution. To treat the blades, de-icer fluid is pumped to a slinger ring and thence distributed to the propeller blades. An electric pump controlled by a rheostat in the pilot's compartment pumps the fluid from a supply tank. This tank must be filled prior to take-off on a flight in which icing conditions are expected. About two quarts of fluid an hour will be sufficient to keep blades free.

Other aids to prop de-icing are: a heating unit for the leading edge of the prop blade (a rubber sheathing with internal electric heating element); alcohol de-icing by means of rubber feed shoe; anti-icing spinners, usually rubber-covered; anti-icing solutions, applied to the dome, spinner, and blade.

The air-speed pitot tube also collects ice. This causes false readings of the altimeter and rate-of-climb indicator, as well as the air-speed indicator. Ice can be prevented by turning on the pitot tube heater. The electrical heater switch is connected through the airplane ignition system in such a way that the heater is "Off" whenever the ignition switch is off.

In case of failure of the electrical air-speed heater during severe icing conditions, an alternate source of static pressure for the operation of the altimeter and rate-of-climb indicator can be used by turning the static-pressure selector switch to the "Alternate Source" position. This device, however, causes the altimeter to read too high, maybe as far off as 800 ft. Clearly, an instrument landing should not be attempted with the alternate source in use for static pressure.

Instructions for the operation of heaters, electric units, defrosters, de-icers, and similar equipment are presented in Section I, "Pilot's Handbook", for each type of aircraft.

Windshield de-icers are equipment for certain airplanes. The system provides perforated tubes through which de-icer fluid may be supplied to coat the windshield. Fluid is supplied through an electric pump controlled by a rheostat in the pilot's compartment.

4. Flying Technique

In general, the handling of an iced aircraft is essentially a matter of maintaining speed and a low angle of attack. The air-flow will continue to adhere to upper surfaces as long as the angle of incidence remains small, but there is generally a very abrupt and complete stall when the angle of incidence is increased, as in landing. So, bring it in fast, and hold it level a few feet off the ground until the stall occurs, making

no effort to achieve a three-point landing. Watch your air-speed. Do not try to climb too fast with a load of ice, because of the danger of stalling. Make wide turns. Steep turns with iced wings and tail surfaces are suicide.

V. LETTING DOWN AND LANDING

Temperature inversions, in which ground air may be 15° to 30° colder than at altitude, are common in the north. When letting down in cold weather, therefore, care must be exercised to keep engines warm during the descent. It is normal to descend with considerable power. This procedure should be the rule in cold weather, since throttle, carburetor, coolant, and cylinder head temperatures will fall rapidly and require excessive adjustment of cowl flaps, oil and coolant shutters. Carburetor icing may occur when the engines are again opened up. Before making your final approach insure that your engines will deliver power normally while you still have plenty of altitude. It is good practice to use oil dilution during a long descent, but this is not to be regarded as a substitute for keeping the engine warm.

It may be found desirable to lower wheels and use partial flaps well in advance of the actual approach, in order to insure that they are functioning correctly, while sufficient altitude remains for emergency procedure if necessary. This also allows use of more engine, which of course, tends to eliminate the probability of carburetor icing.

Attempt to maintain head temperatures above 100°C. (212°F.), coolant temperatures above 60°C. (140°F.), and oil temperatures above 30°C. (86°F.) during all let downs. Land with carburetor heat on or off depending on what is needed most, heat or engine power. The conflict is between possibility of icing and certainty of power loss. Remember, in addition to preventing ice formation, carburetor heat will insure proper fuel vaporization if it should be necessary to go around. Keep the carburetor heat below 40°C., to keep down power loss due to excessive heat.

Land with cowl flaps closed. Open them immediately on landing. Taxi to the line with carburetor heat on.

On a dull day, or when fresh new snow covers a broad expanse of the ground, it is practically impossible to judge height, without some reference point such as shadows or markers. The tendency under these conditions is to fly into the ground rather than to flatten out high. Power landings should not be made until the pilot is familiar with snow surfaces, and thereafter whenever doubt as to the surface exists. Bring it in well above stalling speed, flatten out well above the ground, and permit it to sink gently with engine on until contact is made.

Go easy on the brakes. Application of brake increases friction between tire and snow. The ice and snow melt, freeze into a glaze, and skidding results. The more the aircraft skids, the more friction; the more friction, the more glaze, etc.

Crosswind landings on clear ice require good timing and judgment. Compensate for drift before you touch, and use brakes sparingly.

VI. NAVIGATION

Arctic weather, arctic terrain, and other factors complicate the problems of navigation, and make necessary additional study. Many areas are uncharted, and you will need to keep alert for latest information.

A. Phenomena Affecting Navigation

While topographical features are important, their shapes may be disguised by snowfall. Along the coast a flat shore arm may be difficult to distinguish from sea ice. There is point in flying further inland where some ground relief is visible, or within sight of open water farther out to sea.

Despite common belief, relatively little snow falls in the north each winter; what appears to be a heavy blizzard is frequently a strong wind blowing loose snow from one place to another. Therefore the snow will not be encountered above low altitude. Similarly, violent snowstorms are not common. High winds are almost always purely local, usually where high land faces the open sea. Winds of gale violence generally cover a strip extending not more than 15 miles inland and seaward. Farther inland, strong winds seldom occur, and never in combination with extreme cold. Coast lines are subject to heavy fog in the spring and fall, with moderate fog in the summer. Winter fogs are infrequent.

Pitch darkness occurs in the polar circle only in wide areas of open sea. In the summer there is continual daylight or twilight; in the winter, when both direct and indirect sunlight are absent, the ground is lit up by the snow's reflection of any light that gets to it. Even under these conditions it is commonly possible to see dark objects the size of a person at 100 yards. Arctic moonlight is unusually bright, providing enough light for landing. The Aurora Borealis (northern lights) cannot be depended on as a light source because of fluctuations in intensity, but it might be of some assistance in travel.

B. Aids to Navigation

Make your own additions to maps. Sketch in and identify local features of terrain, i.e. the shape of woods and forest areas, marked changes in the geological, topographical, and vegetational character of the surface. You do not have to be a geologist to remark these differences.

In winter the sun is a valuable aid to navigation, and need not be visible to be used. Shadows indicate the direction of light, and can be readily distinguished on the snow. Bear in mind, however, that the sun is continually in motion, and that a heading by the sun must be corrected approximately five degrees every 20 minutes. For flights of, say, 300 miles, satisfactory results can be obtained by using local time and assuming that the sun is due east at 0600 hours, due south at noon, and due west at 1800 hours, and that it moves 15° an hour.

Observe one precaution, however. Marked changes in density of cloud cover may result in production of a false shadow when the greatest quantity of light comes through from a point to one side of the true sun position.

"Sky maps" are useful indications of ground conditions. A uniform overcast with clouds at a high level reflects terrain. Over level ice uniformly covered with snow, the cloud area shows a uniform white. Broken surfaces, such as pressure regions, pack ice, or drifted snow, are indicated by mottled appearance of the under surfaces of the cloud. Blue or green ice is shown by grayish patches on the sky map; open water, timber, and snow-free terrain, by black cloud areas. Careful study of the sky map can help show the way to open water, snow-free areas, or heavy timber.

Wind direction is usually easy to determine by streaks of light powdered snow blowing across the surface. These show up lighter in color than the solid snow beneath and react quickly to wind change. Snow drifts usually indicate prevailing wind. The smooth slope of the drift faces into the wind, and the steeper side of the drift lies downwind.

"Sastrugi", or small, tightly packed snow drifts 10 to 20 inches deep, looking like ocean waves, are hazards to planes landing, and to ground travel. Landings are possible parallel to the drifts, but are likely to be dangerous.

Be prepared for compass errors caused by areas of mineral attraction, seldom more than 30 miles in extent, but able to render the compass useless or, worse, misleading. Therefore, until you know the country well, maintain constant check by sun and wind directions, and use gyro instruments fully. Dead reckoning will require accurate compass courses and time intervals.

In regions within a radius of approximately 500 miles of a magnetic pole, the navigator should be prepared for increasing sluggishness of the magnetic compass due to pronounced dip of the lines of magnetic force. Small defects causing pivot friction or weakness of the magnetic elements will have a greater effect in those regions than in the lower latitudes.

The rapid change in variation along a flight route must also be kept in mind near magnetic poles. While the usual method of averaging the variation along the route is satisfactory for changes of about five or ten degrees, it will lead to considerable error in the flight line where changes of greater magnitude occur. This difficulty is best overcome by breaking the route down into shorter stages and taking the mean variation for each. From this, compass headings may be calculated for each stage.

Little is known authoritatively about magnetic variation in the higher latitudes. Geomagnetic conditions are unique, and compass directions are subject not only to uncertainties because of the low directive component of the earth's field acting on the needle, but also to large rates of daily change in variation under normal conditions, which may be a matter of degrees. Also, in periods of magnetic storms, fluctuations of 20° to 40° may be expected.

Navigation at high latitudes is further complicated by the rapid convergence of meridians of longitude. For example, within 15° of the pole it is possible to pass through a whole degree of longitude in a few minutes, making it difficult, if not impossible, to arrive at a good dead reckoning longitude and local hour angle.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE ARCTIC (THREE LECTURES)

A-III LECTURE III—SURVIVAL

Prepared by

U.S. THE ARCTIC, DESERT AND TROPIC INFORMATION CENTER

OFFICE OF ASSISTANT CHIEF OF AIR STAFF, INTELLIGENCE

25 BROAD STREET, NEW YORK 4, N. Y.

THE ARCTIC

Lecture III:
Survival

I. CENTRAL THEME (THE COLD) AND SOME PRINCIPLES OF SURVIVAL

Survival in the arctic presents a narrower, more intense problem than in any other area. There is one central factor--the cold--and keeping warm and alive and effective depends on mastery of a small number of principles springing out of this factor. In the desert there are heat, dryness, cold, insects, sand; in the tropics there are heat, excess moisture, insects, disease. In the arctic there are the dangers of freezing, getting lost and exhausted because of snow and storm--all related to cold.

Clearly, this central fact makes the problem of survival simpler, but of course not necessarily easier. It is not hard to learn and apply the lessons necessary for life in the arctic. The basic problem, how to combat the effects of climate, can be divided into a series of related principles and techniques. Understand these first, and you can go on to learn specific details on what to do at any special time. The end result of this lecture should be that you know you can master the cold, and need have no undue fear of a force-down, or separation from your unit. Know how, and come through.

A. An Illustration

One of the best known stories of survival and rescue after a crash in the snow is the experience of the B-17 crew who lived through five months on the Greenland icecap. Wounded, frozen, suffering, facing sudden death every day as cracks in the ice developed right under their crashed plane, their rescue thrilled the country when it was announced last spring. But without any intention of detracting from the men's courage, we must emphasize their own admission that if they had taken certain precautions, and known certain simple facts, they would have suffered less during their stay, and would have escaped some of the injuries they received.

While helping search for a lost transport plane, their B-17, being ferried to England, crashed on the Greenland cap near the west coast. The plane broke in two. One man was thrown clear, broke his forearm, and because both his gloves were lost as he lay in the snow,

he froze both hands. While helping carry this man into the plane, one of the lieutenants of the plane got snow in his boots, and he did not dry them out. The men remained in the plane that night, but were made miserable by fierce wind and penetrating drift snow. They were on short rations, having lost two of their three boxes of food, had packed no sleeping bags, no extra clothing, no stoves--nothing but flying equipment; and that was winter, not arctic equipment. They had a jungle kit on the parachute, and first aid material. A couple of days later two officers went to look over the land, and one fell into a deep crevasse, escaping death by the chance of hitting an ice ridge part way to the bottom. A parachute harness and shrouds, and a jungle knife helped get him up. On the third day, the lieutenant who had got snow in his shoes, took them off, thinking his feet might be frozen. They were. The plane commander took the frozen feet under his armpits and rubbed them for two or three hours. They began to soften up and turn all colors.

On the eighth day the radio operator, a corporal, by great ingenuity and perseverance, got the radio working. They made a contact with outside, and on the fifteenth day a plane came over and dropped much needed sleeping bags and food. About a week later two of the men were sent out with a Coast Guard pilot who landed nearby; after another trip in, this pilot was killed, with the radio man of the B-17. An officer, with much Greenland experience, was lost in a crevasse just as he was approaching the crashed plane on a rescue motor sled. Another man of the crashed crew was killed when he fell into another crevasse on helping a second sled move out the lieutenant with the frozen feet. The sled party was marooned about four miles from the plane. At this time, after three weeks of freezing in the plane, the men dug a hole in the snow under the plane wing, and lived there. After unsuccessful attempts to reach the men, and more than another month of dropping of supplies from the air, a PBY under the command of Col. Bernt Balchen, the famous arctic and antarctic explorer, was belly-landed on the snow near the sled and picked up the three men there. The plane could not return until April, almost two months later, when by amazing methods it was got off the snow with the men left at the wrecked B-17. The lieutenant lost both frozen feet.

We shall not point the various lessons of this story, but suggest that you try to think what you would have done, on the basis of what you hear in the rest of this lecture.

B. Some Principles of Arctic Living

These following basic principles of behavior in the arctic have application whether you are at your base camp, or huddling in your crash-landed plane waiting to be found and rescued. Either way, be aware of your surroundings, and use what you know.

1. Do nothing alone. If you can help it, have someone with you wherever you go. An injury can put you out of commission faster in the cold than under other conditions. You need someone with you to help if you are hurt, to go for aid. Important too is the need to have someone repeatedly looking at your face in the cold. Not to draw inspiration, or a laugh from it, but to inspect for frostbite.

In extreme cold, flesh can freeze in a couple of minutes, without your knowing it. If it is treated quickly, the freezing will leave no permanent harm. On ice-covered areas like Greenland, improvise skis or snowshoes until you are sure no crevasses exist underfoot.

2. Train in Self-Control. Learn what is the right thing to do in any circumstance, and do it. Make yourself wear the right clothing. When the time comes, you will act on your knowledge that you should stick by your plane; that you should not fight against a storm, or travel when the weather is bad. Habit is as important as simple knowledge in preventing panic.

3. Weather Is Changeable. This is especially true in the Aleutians, over which there will continue to be much traveling. Even in inland Alaska, where weather changes occur more slowly, the temperature can fall ten or twenty degrees in an hour or two. Do not go out unprepared, with wrong or insufficient clothing, even if you are only taking a bus from camp into town for a date or a movie on a mild afternoon. Frostbite hits the careless.

4. Frostbite Is Quiet. Freezing of the flesh can come fast, when you least expect it, and may lead to the loss of an ear, a finger, or a foot. Or your nose. What happens is that an area of skin, and flesh beneath it, is frozen, so that blood does not circulate. When blood does not feed tissue, that tissue dies. Dead flesh rots, and the rotted area may spread to live flesh next to it. This is the reason for preventive amputation of decayed or gangrenous parts of the body. Keep the body warm and the blood circulating, and keep watching for frozen areas on the faces of those about you. Touching cold metal with bare skin, or exposing the skin to propeller wash, will bring frostbite, because of the extremely rapid loss of heat from the skin.

5. Chill Brings Illness. The lowering of temperature of the skin, even a part covered by clothing, may kill tissue, and it may also lead to broader danger. It can lower body resistance and leave you open to colds and pneumonia. Chill may come in several ways: insufficient clothing; clothing too tight, causing insufficient circulation of blood; accumulation, then condensation of body perspiration. Chill may also result from exhaustion after too long exertion in the cold, without rest. Body resistence goes down, and weakness results.

6. Clothing Is the Secret. You will soon learn that you must depend for warmth not on fuel and stoves, but on your clothing. Clothing must be correctly chosen, and properly worn. The principle of correct clothing is not thickness to keep out cold, but rather insulation, dead spaces of air between the body and the outside. Several thicknesses, with air spaces, are preferable to single heavy garments. Tightly woven, wind-proof outer covering helps retain air spaces underneath.

Wear your clothing properly, too. Beware of too much protection. Get used to a cold skin, because a cold skin will be dry. When you exercise, loosen garments, or remove some, lest you perspire.

C. It Isn't True--Some Misconceptions

These basic principles of life in the north listed above can be emphasized by the listing and analysis of a number of false ideas that have dug into people's minds. False knowledge is more dangerous than ignorance in time of emergency, because it may lead to more rapid disaster.

1. "The North is Frozen! Nothing Lives There." This idea is less widely held than it used to be, but still it is necessary to point out some facts. There is life--animal, vegetable, and human--all over the arctic areas, though sparsely distributed in some areas. Most of the area is comparatively dry; snow does not keep falling in blizzard proportions. There is less rain and snowfall near the North Pole than in most parts of the United States. In winter, storms seldom last more than a couple of days, except in Greenland. There is a definite summer season; during August more than eighty per cent of the land north of the Arctic Circle, excluding Greenland, is free of snow. Inland temperatures may go higher than 90° F. and in sub-arctic valleys a great deal of cultivation is possible.

2. "Fall Asleep in the Snow and You Won't Wake Up." This has been proved false again and again. Eskimos sleep in snow on the trail every night. Sometimes during a strong storm they simply dig a hole in the snow and go to sleep. When your sleeping body gets too cold, you will wake up. But if you are exhausted, and your regulating mechanism impaired, you may be chilled and frozen. Moral: Take it easy, and rest, so that your body will be in condition to give warning.

3. "Once It's Below -15°, It Doesn't Matter How Cold It Gets." More nonsense. Explorers and travelers remark a definite difference between -20 and -30, shown in the increased difficulty of melting snow for water, the increased danger of frostbite, the greater speed of chill.

4. "Rub Frostbite With Snow." This is a dangerous misconception, involving a double risk. The snow is likely to increase the freezing. And worse, rubbing damages the frozen tissues, thus opening the possibility of infection. The damaged tissues may even become gangrenous. Do not rub frostbite with snow--or with anything else. Proper treatment is to warm up the frostbitten part gradually.

5. "You Can Always Get Water by Melting Snow." True, but not so easy as it sounds. The colder it gets, the harder snow is to melt; and you need a lot of snow for a little water. Use ice instead. Eat snow or ice slowly.

6. "Clothing Should Be Waterproof." A good ticket to the hospital. Waterproof clothing will act, even in the coldest weather, like a rubber raincoat--you may be as wet inside from body moisture as you are outside from rain. If clothing is not porous, body moisture will not evaporate, but will condense, and chill.

With these principles and fallacies in mind, let us follow the program of what to do to survive in an emergency. Most dramatic of

difficulties is being forced down in a disabled plane in a cold waste, but there can also be the situation of the traveler who gets lost either near or far from his camp.

As in all cases of emergency, it is the man who keeps calm who has the greatest chance of getting through. And the man who has the greatest knowledge and the best training is the one who keeps his head. What you know about, you are less likely to fear. Right now, start studying and thinking; and when you get to your first station in the north, start practicing what you have learned. Then being lost, or simply living in the Far North, will approach being part of the day's work for you.

II. PREPARATION FOR TROUBLE

In time of safety, prepare for trouble. The best time to start learning what to do when you are forced down or lost in an arctic waste, is now. The second best time is when you are at your Northern station. Further, what you learn now and in the North means little unless you practice it. Let us repeat until it is painful: Knowledge is of small value without training. Somehow, knowledge alone dribbles away, deserts or evaporates when an emergency faces you; but training and habit cannot desert you. So what you hear, and what you read, must be tried out, and on yourself, not on the buck private or the Pfc. who happens to be around.

Proper preparation involves (1) choice of proper clothing, and training in its use; (2) gathering of equipment to be used for ordinary life in the arctic, and also (3) emergency kits. Later sections will deal with what to do when forced down, how to signal, how to get food, how to prepare it; how to keep warm and make shelter; and how, as a last resort, to travel, if travel is necessary. A separate section will deal with what modifications of these procedures are necessary for summer existence.

A. Clothing

The principles of proper clothing for extreme cold have already been stated: sufficient insulation, looseness, adjustability. The amount of clothing should be aimed at taking care of the body when it is at rest, without the added heat of body exertion. During exertion, such as work or movement, the clothing will have to be loosened, opened, or even some of it removed.

1. Body Clothing. Some questions arise in the discussion of clothing to be worn by soldiers in cold climates. First, and most obvious, is: What is available? How much choice is there? Then how to choose? What combinations to wear--what underwear, what basic clothing, how many layers of outer clothing?

Available clothing depends on several factors: supply procedures, closeness to depots, and also the results of continual experimentation and revision of requirements. Both Air Force and Quartermaster Corps are at work on the problem of adequate clothing, and changes are to be expected. All we can do here is suggest the general types of clothing likely to be available, and how they can be put to best use.

Underwear is of the usual two kinds, light summer, and woolen winter. Experts agree that for daily wear around the post either kind may be worn under ordinary uniforms, depending on the temperature of heated buildings. Usually the woolen underwear is worn, when there is no special arctic outside clothing. In field or flying work, when the heaviest outer garments are necessary, it is advised that light underwear be worn, since sufficient warmth is supplied by the outside clothing.

Great variety has been found in the choice of basic clothing to be worn immediately under the heavy flying suit. The tendency among flyers has been to wear ordinary post uniform of slacks, and blouse, or leather jacket, or other unspecialized clothing. Special basic clothing is being provided, and specific recommendations are being made as to the best combinations, in order that the value of the heavier outer garments be not offset by improper clothing underneath. It is likely that no clothing at all will be found necessary between underwear and specialzed arctic as distinct from winter flying clothing.

Flying clothing is of several kinds: (1) quilted suits, filled with down or cellulose acetate; (2) the arctic alpaca-pile parka; (3) wool-pile parka; (4) electric-wired suits. There has been much variety of choice, not always wise, by individual pilots, both of outer clothing and that worn under the flying suits. Light underwear, and woolen shirt with warm trousers are recommended.

For general wear in both extreme cold and temperatures around zero, the most successful outer combination is the Alpaca Pile suit. This is composed of six parts, three parkas and three trousers. The inner section is an inner pile parka, with hair-side toward the skin. The middle section is the outer-pile parka, with hair-side facing out. The outermost or cover layer of coat and trousers is made of a tightly-woven, windproof and rip-resistant thin cloth. This layer is indispensable to maintain warmth of inner garments. The alpaca pile is a manufactured product, with closely-spaced fur-like hairs acting as an insulator. It is like the beaverette, or artificial thick fur, used in civilian heavy overcoats.

The suits are so constructed that any combination of parts can be used. The usual procedure is to remove either the inner or the middle unit during exertion, to prevent overheating of the body.

Natural fleece suits, called shearling, are available in small numbers, but are considered to give less warmth than the alpaca pile combination. Each layer is fairly bulky. A garment popular with ground-crew men is the alpaca-pile lined overcoat, longer and fuller than the parka.

It should be remembered that the maintenance of air insulation is the secret of warmth. One way of preventing overheating is to use this principle in reverse--circulation of the air-spaces will cause cooling and the dissipation of body heat. Clothing should therefore have facilities for easy opening to allow air to circulate. The pile parkas are made with a drawstring at the bottom edge. The wearer tightens the

string when he is at rest, and loosens it, to allow circulation, when walking or working. Or in warmer weather he discards one or two garments completely, depending on the amount of body heat given off.

A full treatment of standard winter clothing for northern service is found in Training Circular 37, March 19, 1943.

2. Feet. Incorrect footgear has probably been the cause of most freezing of the feet. Proper care of the feet is extremely difficult in cold climate, for two reasons: the weight of the body, and the movement of the feet, make the maintenance of a dead air insulation space impossible; and moisture is almost unavoidable. Thus footwear presents a continuous problem.

One common error is to have the footwear too tight, thus hampering circulation and limiting air space. This is one reason why in extremely cold weather ordinary G. I. shoes should not be worn at all; they do not permit wearing of a sufficient number of layers of socks. In temperatures much below zero the best footgear is the Eskimo mukluk, a non-waterproof, spacious high boot. It permits use of felt insole, and several pairs of socks. It is best in low temperatures, when snow does not melt and wet the boot through. Mukluks should not be worn indoors, or they should be whisked clean of all snow and ice, lest snow melt, wet through the inside, not have time to dry out completely in the warmth of indoors, and then freeze when worn out in the cold air again. The mukluk, either of skin or canvas, is ventile--that is, it "breathes", permitting the evaporation of perspiration.

At higher temperatures, around freezing, the shoepac is advisable. This is a boot with rubber bottom and canvas or leather uppers. The bottom keeps out moisture from slush and wet snow, but of course keeps in some moisture from the feet. The wearer should dry out the feet, the inner soles, and the socks as often as possible.

There are also felt overshoes, which can be worn with one or two pairs of socks under waterproof overshoes, in case of wet ground.

As important as the kind of shoe are the socks and insoles. Insoles, usually of felt, are needed to furnish insulation under the foot. They must be kept dry and clean. The wearer must have an extra pair along, to wear while the first is being dried out. The drying can continue even while on the move--for even below zero, air and sun will dry damp articles, and a source of warmth is found beneath a parka, well ventilated to keep the moisture evaporating. Insoles should also be changed from foot to foot, to distribute pressure and the matting effect.

A light weight woolen sock with double soles should be worn next to the skin. Depending on the temperature, one or two pairs of woolen ski socks should be worn over these. Then on the outside the jute or net sock should be worn. This is a hard-weave material, and is useful in helping condense moisture from the feet. The moisture freezes and gathers on the net, which can be shaken and the frost knocked off. Another sock, used only in extreme cold, is the felt duffel sock, worn under the outside net sock. It is useless when wet.

One important precaution. Clothing, from socks to parka, loses warmth when dirty or greasy. Socks lose their insulation as dirt mats the wool fibers, and grease is a good conductor. So keep clothing, especially socks, clean. Wool should be washed in lukewarm water, and shaped. Make sure that all the soap is out.

In summary: the best combination is a ventile, loose high boot (high enough, and with a drawstring at the top, so that it will not fly off in case of a bail-out), with several pairs of socks underneath. Two pairs loosely worn are better than three tight pairs. Insoles are indispensable in cold weather. The top of the boot should not permit snow to enter.

A good insulator has long been used by the Eskimos--grass. Tufts of dry grass are put in the shoe, outside the socks, and serve to keep air spaces working.

3. Handgear. It is hard to hit on a single specification for gloves, because of the various kinds of demands, ranging from flyers to ground crew to gunners. The same basic principle applies in handgear as in other clothing: it must breathe, and allow escape of moisture. Completely waterproof gloves or mittens cause condensation, and maybe freezing. Mittens cause each finger to help warm the others, while finger gloves, with less air space, are not so warm. Standard issue is a combination of heavy mitten and thin water-repellent shell, both with trigger fingers which can be drawn inside the mitten.

A good combination is a thin, tightly woven woolen glove to furnish an insulated layer, and an outer loose mitten of windproof cloth, horsehide, or skin. Mechanics' and ground crew's mittens must be sturdier and oil resistant. In cold weather the wristlet, covering the wrist and forearm, but leaving the fingers free, is useful, and should be worn at all times.

Great care must be taken to sew up any holes, no matter how small, in the material of the mitten. Even the smallest area of live tissue exposed to the cold can freeze, and the hands are especially liable to freezing. One authority on arctic clothing has suggested that a suitable needle and thread be attached to each garment or set of garments, to assure quick repair of holes.

Another precaution is to tie gloves and mittens to the outer clothing with string, to prevent their loss in the snow. A lost mitten can cause the loss of a hand, and a useless hand in an emergency can cause the loss of life.

4. Headgear. Several examples of frozen ears have been reported at Alaskan air bases, the result of wearing simply a garrison cap for even a short stay outdoors. It seems an obvious enough caution--keep your ears covered when the wind blows free. But momentary lack of control, a single careless decision, accompanied by a quick change of temperature, results in a disabling frostbite, with some days in the hospital, N.L.D. This is where habit and training come in--for so small a decision as the choice of a hat. Woolen toques, or pull-over stocking

hats, are available. Our ears, with blood running close to the surface, are in especial danger of freezing. Ski-hats, with ear flaps, can also be worn.

Hoods are available to go with parkas for really cold weather. Some difficulty has been experienced with hoods that do not fit either the wearer or the parka itself. Hoods must be fitted to the individual and his garment. A fur fringe, to furnish a kind of insulation around the face, is useful in extremely cold weather to help prevent frosting of the face. But of course eternal vigilance is necessary, for those whitish-grey, dead areas of skin.

B. The Sleeping Bag

An indispensable part of field equipment is the sleeping bag. Several varieties are available. The Quartermaster Corps model consists of a double bag. During fairly mild weather only the inner bag is necessary. For extreme cold the outer bag is slipped over this, affording extra protection. The Air Forces bag is heavier and bulkier.

The user must be careful that the bag has adequate closures. Wind pushing its way into the bag through a slight opening can reduce body temperature to a point at which sleep is impossible. Another basic consideration is the need for keeping the bag dry and clean. Always be sure that you sleep so that your breath is exhaled outside your bag.

Body moisture and its condensation suggest the wisdom of sleeping in clothing. But never sleep in clothing you have worn during the day. Put on fresh dry underwear and clothing if possible. The clothing absorbs moisture, and can be changed, while few bags come equipped with interchangeable and cleanable linings. For this reason, reliance on the sleeping bag in a permanent camp will be quite unsanitary, if the bag is used for weeks without cleaning.

C. Emergency Equipment

In considering kits and equipment, let us take the normal situation first--that a plane in trouble will be crash-landed.

1. The Plane Kit. The basic advice in an arctic emergency is to try to land the plane, in order to have the benefit of the shelter which the fuselage affords, plus the added equipment which the plane can carry. A combination of three airplane kits now available offers a good basis for a prolonged wait for rescue.

The first, Emergency Sustenance Kit (Rations), Type E-1, provides rations and miscellaneous equipment. It is packed in a fiberpax drum, and contains various rations and drinking water. It includes 2 of each of the following: waterproof match box with matches; hunting knife with sheath; mess kit; mosquito headnet; pair of water repellent canvas gloves; mosquito repellant; fork; spoon; pair of mukluks; ice creepers; box of 24 heat tabs. Also a sewing kit; a grill for the heat tabs; and a copy of a survival manual.

The second, Emergency Sustenance Kit (Implements) Type E-2, is carried in a metal container which will serve as a wood stove. Of

course Greenland and other areas without wood offer little possibility of use for this stove. Contents: combination .22 cal. and .410 gage gun; ammunition; matches in match box; camphor; generator-operated flashlight; candles; stew pan; large spoons; machete or butcher knife; cooking oil; fishing kit; signal flares; axe; gasoline-burning stove; first aid kit.

The third is the Emergency Sustenance Kit (Cooking) Type E-4, an emergency cooking unit employing a pressure type gasoline stove burning 100 octane gasoline, and including two stew pans, a fry pan, and a fabric gasoline bag.

It is apparent that there is overlapping among these kits, and when space is at a minimum, as in fighter planes, it might be advisable to arrange a combination of contents. Addition of other items can be arranged, in accordance with the experience of those who know the problems to be faced. The Airlines War Training Institute suggests the following items: axe; shovel; rockets; Very pistol; metal signaling mirror, with small hole in center; V-K smoke signals; candle; gasoline stove and container; gun; four ounces light flexible wire for snares; fishing kit--Pinchot-Lerner No. 5 light weight for rafts (Instructions, net knife, hooks, bait, and cloth gloves). Also a first aid kit: burn injury set containing sulfadiazine ointment (also useful in treating infection from frostbite); 3 packages small first-aid dressings; 1 wet eye dressing; 100 halazone tablets; 2 ampoules of morphine; 1 pair scissors; 1 pkg. sulfadiazine tablets (to be taken when wounded); 1 pkg. sulfanilamide powder (to be sprinkled on wounds); 1 tourniquet; 1 large gauze adhesive bandage; 1 box iodine swabs. In addition, a sewing kit (large safety pins, needles, cotton, darning wool, buttons).

Individual equipment includes a pair of snowshoes, a sleeping bag, and two pair of amber sunglasses with non-metallic shields at edge. A pocket compass is an important item, in case it becomes necessary to leave the plane and travel.

A technical sergeant who walked 150 miles to safety after a forcedown, recommends many of the items above listed, and in addition, linen thread and curved fabric needles; six candles; colored signal panels; and a rucksack.

2. The Parachute Kit. The Basic Parachute Emergency Kit, Type B-4, can be of real value under certain conditions, especially when rescue is to be expected in a short time. It goes with the seat or back-type parachute, and is enclosed in a zipper-fastened canvas cover, usable as a knapsack after landing. Contents are signal flares; signal panel; a machete; special parachute kit ration unit made up of Field Ration K components; match case with matches; cooking pan; compass; knife; fishing kit; can of solid fuel; first aid kit; mosquito headnet; goggles; and gloves. There is no sleeping bag or extra clothing, of course, and if extreme cold weather sets in, the only protection would be a snow-house, since a fire cannot make itself felt more than a foot or two away. Fighters can stow little more than this kit.

There are also the personal kits, escape type, designed to be carried in the pocket or snapped on the chute harness. Type E-3 is

packed in a cloth bag, 12" by 6", which can be used as a water container. It contains matches, compass, hacksaw blade; halazone tablets; benzedrine tablets; Field Ration D; dextrose tablets; bouillon powder; chewing gum.

Type E-6 Individual Bail-out Ration contains two units of Field Ration K, which can be snapped on to the chute harness before bailing out. Type E-7, Individual Bail Out Water provides two cans of drinking water. This is likely to be of least use in the arctic.

Of course the components of all these kits are undergoing constant testing and experimentation. Some kits may be discontinued completely, or revised. It is further obvious that only a limited choice of kits might be available at any one time or post. Individual airmen will have to make up their kits from what is available. But the basic needs are clear: matches, compass, basic rations; some container for melting water and cooking, a hunting knife and sewing kit, sun glasses, warm clothing.

3. Rations. No plane should start on a mission in the arctic without storing as great a quantity of rations as possible. You do not know, when you start out, how long it will be before you come back. It is difficult to say ahead of time what should be taken. The standard kits have been found satisfactory: the five-in-one ration, intended to serve five men for one day; the Field Ration K, one box for each meal; and the C ration. It has been found that these rations can be stretched without causing too great weakness.

Certain basic principles should be followed in an arctic diet. Most striking is the need for fat, to furnish quick heat. A diet of rabbits, affording only lean meat, is deficient in components other than protein. Sugar is an important item, for energy. Most northern explorers are emphatic in their approval of hot tea as a source of body warmth and as a stimulant.

Pemmican, a concentrated combination of ground and pressed lean and fat meat, and cereal, has long been a popular form of emergency food. Bouillon cubes and dried fruit are also approved.

Vitamin concentrates are favored by some men who have traveled in the arctic, but there is no clear proof that they are necessary for brief periods, or on permanent bases.

You can expect to lose weight during an enforced stay in cold weather. Most of the loss of weight is due to loss of water. Besides, the difficulty of making a fire and thawing food, and the time consumed, will keep your food intake down. One of the rescuers who joined the Greenland B-17 party actually gained weight during the months awaiting rescue. He was experienced in arctic living, and could make the best of his situation.

III. THE FORCE-DOWN, AND METHODS OF SIGNALING

Let us assume that you have done your best to equip the plane with the proper equipment: sleeping bags, clothing, food, implements. Needless to say, you also need training in how to use all this material. A suggestion has been made that every pilot entering arctic operations should receive a week's training in living in the wild country, learning how to wear clothing, make fires, adjust his tempo of living to the weather. This may not be feasible; but officers can take it upon themselves to learn as much as they can, and practice what they learn, about equipment and how to use it. Ground crew men receive special training in maintenance and living problems.

A. Stay with the Plane

The first advice, in case of trouble, is, Stay with the plane. Do not let go of a prefabricated shelter. If it is at all possible, make a landing when the plane is in trouble. Or, if you have to bail out, try to find what is left of the plane. Besides the factor of shelter, there are other reasons for staying with the plane. First, it is easier to spot in a search than an individual. Several inhabitants of the far north, accustomed to travel, remember cases in which the empty plane was discovered long before the person who had left it to try his luck cross country. This is a unanimous opinion.

Second, your plane has important equipment that you cannot attach to your parachute. It has,or should have, sleeping bag, extra clothing stoves, fuel, food. This does not apply to a fighter, of course.

1. On Landing

Well, the plane has been landed. Or, you have bailed out, and you have found your way to the crashed plane not far off. The first thing to do is to make sure there is no chance of fire. Look for escaped gasoline. Move the equipment out of the plane until you are sure there will be no fire--fire can break out some time after the crash.

Make sure immediately that everyone in the party or crew is adequately dressed. A few minutes' delay may cause dangerous freezing. But adjust your clothing to keep perspiration at a minimum. At the same time, render whatever first aid is necessary for injuries sustained in the landing. There is less danger of infection in the arctic than in other areas, but wounds are likely to freeze quickly, stiffen, and cause trouble out of all proportion to what one would ordinarily expect. Shock is especially dangerous.

An important job to attend to quickly is to moor the plane. Winds can spring up quickly and cause great trouble by blowing the plane around and wrecking your camp. If possible, use a "dead-man" mooring. Dig a hole in the snow, bury a log, or barrel, or chunk of ice, or anything to which you can attach the end of a rope, pour water over it, to freeze it, and then fill the hole; tie the other end of the rope to the plane. You will need several such moorings to hold the plane steady. Where no water is available cut two trenches in the ice parallel to each other, about six to ten inches apart and from one to two feet deep. Then chisel a hole through the bottom of the wall or segment of ice between them. The rope will go through this hole.

2. Keep Feet Dry

Do not try to travel too far away from the plane. You can easily lose your way. And above all, if you do want to go to the top of a nearby hill to look around, do not make the mistake of one fighter pilot. His P-36 was forced down, with very little damage. He was uninjured. He decided to walk around, inspect the plane from the outside, and try to get a view of his surroundings. He returned to the plane, wrapped himself in his parachute (he had no emergency clothing along), and waited. He neglected to dry his shoes, or remove from them some snow which had got in. After a while his feet felt cold. When he lit a fire and took his shoes off, he could not melt out the snow, which was frozen solid.

When he was finally rescued, his feet were frozen to the ankle. He was lucky in that he lost only his toes; but the Air Force lost a pilot. This trouble could have been avoided with the simplest knowledge. If you walk out in the snow, make sure none gets into your shoes.

3. More on Frostbite

The important thing, next to preventing frostbite, is to discover it as soon as possible. Almost all stories of frost-bite reported to medical authorities in Army camps in the north have a similar element: the patient did not know his feet were frozen, or his hands, or his ears, until hours later. Either there was insufficient, or too tight, foot covering; or the patient lost a glove, or took his mitten off in extreme cold to do a small job, and left the mitten off too long.

If you suspect a part of your body is frozen, act immediately. If your hand has been exposed to the cold for a couple of minutes, do not simply put the glove back on. Dig your hand deep into your clothing, next to your body. If you twitch your face, and feel that there is a dead area, without sensation, take your warm hand out of your glove and hold it against the critical spot. But put the hand under your clothing after a couple of minutes, and use the other hand to warm your face. (Make sure meanwhile, of course, that your mittens are attached to your clothing with a string, so they will not be lost.) Ordinarily, when the freezing has just begun, body warmth is enough to restore sensation. There will probably be pain in the frozen area; this pain is an indication that the operation has succeeded. There may be a discoloration, as in sunburn, a day or two later, and perhaps peeling. There may be swelling, and blistering, if the freezing has been moderately severe.

Above all, avoid panic. The first thing not to do is to remember the old wives tales on how to treat frostbite. Do not rub it with anything. Neither snow, nor oil, nor kerosene. Somehow the quaint notion has grown up that if a liquid does not freeze solid, then it is really warmer than the surrounding air. This is dangerous nonsense. Once a trapper froze a couple of toes. Some one brought in a can of kerosene from outside, where it was at least 30° below, and put the man's feet into the can. The feet froze solid above the ankle, and had to be cut off. Body heat is enough to bring up the temperature of the frozen member. Or apply cold water. Water, to exist as a liquid, must

be above freezing, and therefore probably higher than the frozen part's temperature. Bring up the temperature gradually. Do not work too fast. Even if the frozen area is dead, and requires amputation, do not hurry. It is not like infection, which quickly spreads and contaminates neighboring tissue. The surgeon can observe the area for days, to make sure that cutting is necessary. A clear line of demarcation is observable between living and dead tissue. Do not act dramatically, with pictures of a life-or-death amputation of a frozen leg, by flickering candlelight. You will probably find, if you wait, that the part does not need cutting at all. After sensation is restored, treat the skin as for a burn--the quick removal of body heat from a part does the same thing to the skin that a burn would do. Sulfathiazole ointment is often used by northern physicians.

B. Signaling

An important reason for staying with your craft is that it helps bring rescuers. Even a pea-shooter makes a bigger blotch on the snow than a man. And you can make it more obvious.

1. Scrape off the paint, and make the skin shine. Take off the engine cowling, especially in a multi-engined plane, and lay it concave side up, so that the shiny surface reflects light.

2. Keep the plane free of snow, especially the shiny and darker sections.

3. A useful item in emergency equipment is orange paint, which can be seen from far off. Spread some of it on the wings.

4. Wing covers are now available in two colors: one side is white, for camouflage against the snow. The reverse is orange or a similar bright color, to attract attention in an emergency.

5. Use some of the engine oil for a smoke smudge. Sop it up in seat cushions, or in some cloth, and set fire to it. Alternating this smoke with steam made by dashing snow or a spray of water on your fire, will be a good signal.

6. Use your feet to stamp out an S.O.S. on the snow. Just a couple of inches depression in snow may at certain times of the day and year cause a pronounced shadow outline. Of course this S.O.S. has to be large enough to be caught from the air, about 100 feet. If there is enough brush or wood around, outline letters with this. Only be sure to keep the dead, light wood for your fire.

7. Use your smoke bombs; only use them sparingly. Make sure you hear a plane coming before you let go.

8. Some planes are equipped with emergency rockets. They make excellent signals. Flashlight batteries lose much effectiveness in great cold.

9. Flat signal panels. Learn the various foldings for signals.

10. Signal mirror. Learn how to direct the flash.

11. Probably most important is the radio. It is worth all the effort you can give it, to try to get it working. The B-17 crew which hit the Greenland ice-cap, and stayed there for several months, agree that their rescue was due to the radio operator, who finally coaxed the set into sending out feeble signals. Look for the Tech Order on the plane set. It will help you make repairs. An emergency set, the life-raft Gibson Girl, is good to have around, because of the hand-operated generator. Radio is important because visibility in the north may be bad for days at a time.

IV. HOUSEKEEPING

The next problem, after you have made your forced landing, and have adjusted clothing and arranged signal apparatus, is to set up housekeeping. You may have a long stay. The first thing to do is adjust your minds to the new situation. You are in trouble, certainly. But with knowledge and common sense, it need not be serious trouble. You are not exposed to dangerous insects and germs, or to bad water. Your main enemy is the cold, and if you have prepared adequately, you can laugh at it, or at least face it steadily. Do not be discouraged. Even if the weather is bad, and you begin to wonder if you will ever be found, remember that bad weather seldom lasts more than a few days at a time in most of the arctic area. In the Aleutians, we all know, visibility may be bad for a long time, but the very element that make for fog--closeness to water--prevents the temperature from getting unbearably low.

A. Keeping Warm

1. Keep Dry. This warning cannot be repeated too often. Keep dry outside your clothing, and inside. Do not let the snow remain on your clothing when you move near the stove or the fire. Try not to work so fast that you will raise a sweat. It is the established practice of Eskimos and experienced travelers to start moving fairly slowly, making constant adjustment of clothing, so that the air spaces in the clothing will not become saturated with moisture. If you have to work fast to move equipment, and if you do feel yourself sweating, try to change your clothing, and dry the moisture as soon as you can.

You must be especially careful of your feet. They are most likely to freeze without your knowing it. Take off your footgear, socks and all, before you go to sleep, and dry them out. Remove the insoles daily, if you have them. Dry them out, switch them in your shoes. Do not grease your boots: this will cause them to freeze and get stiff, and lose ventility.

2. Using Snow for Warmth. It may seem strange at first, but in extreme cold you are better off dug into the snow, than in the fuselage of the plane. It took the Greenland B-17 crew a long time to learn this. Extremely cold air penetrates any opening, and your plane is hardly likely to be sealed. Thus the inside of the plane is likely to be as cold as the outside, and it does not make sense to keep a stove or a fire going when you can keep warm without it. The Eskimos learned long ago that snow is a good insulating material, since it contains much air. They simply dig a hole in the snow and go to sleep, when the weather is too bad for travel. Learn to sleep in the snow. However, do not lay your sleeping bag directly on the snow, for two reasons. First, your body may heat the snow under you, causing it to melt slightly, and penetrate the material, causing chill. Second, since the snow is colder than your body, it will draw off heat. Find some kind of vegetation--spruce boughs, or grass, or brush, to lay beneath your sleeping bag. A tarpaulin, or a parachute, or even your arctic suit, will furnish enough of an insulation beneath your bag.

3. Metal Instruments. Keep your watch, compass, and other delicate machinery inside your clothing, preferably on a string around your neck, to keep them warm. Oil will freeze at low temperatures. Guns

should be kept nearly free of oil. They must be clean, and whenever possible the barrel should be cleaned with hot water and thoroughly dried. Once the oil has been removed from a firearm, the piece should not be brought into a warm place, because it has no protection from moisture. As long as it is clean and cold, it will not corrode.

B. Keeping Alive

You will have to keep warm inside as well as outside. Your body engine needs fuel. And at no time is it so important to have hot food as in cold weather. The first requirement, then, is to make a fire, and keep it going.

1. Making a Fire

The old primus stove, burning kerosene or such heavier fuel, is now being supplanted in emergency kits by gasoline stoves, which can burn the fuel used by the airplane engines. This is usually 100 octane, for tactical planes. Other stoves do not burn leaded gas.

But if you do not have a stove, do not think you cannot utilize gasoline. A device used both in the north and on the desert is the sand-wick stove. Fill a tin can about half full of sand or earth, punch small holes for draught in the sides just above the level of the sand; and pour the gasoline on the sand. Then light the top of the sand, which will act as a wick. The stove burns evenly and cleanly.

Apart from gasoline, there are other kinds of fuel. We must consider these because running out of gas is a common reason for forced landings.

In wooded country, such as the sub-arctic, look for trees. Dead wood, dry, is the best kind. Water-soaked and frozen wood, even if dead, cannot be got to thaw out and burn. A dead tree or branch is your best bet, because the wood probably has not been sopping up water during the summer. Finely split green wood may burn after some coaxing. When the wood is snow covered, you can tell the difference between usable wood and worthless stuff, by rapping it with a knife or another piece of wood. Good stuff is light, and gives a flat sound. Water-soaked wood is heavy, and rings when rapped.

A fireplace for a wood fire should have a reflector of logs, and a platform of logs, to prevent the fire from sinking into the snow. The fireplace is also necessary to confine the heat to cooking pots.

In open country, where there are no trees, look for heath shrubs and lichens. There might also be free coal, and peat. If you are near the shore, search for drift-wood. As a last resort, and if you have enough food, use animal fats for fuel.

A fireplace for fat burning could be a stove, or a pile of bones or sticks. If the fat is melted, and dropped slowly on the pile, it burns.

In wooded country, tinder can be made from birch bark, dry twigs, dry rotten wood. On open tundra, white heather or lichens can be used for kindling. A cloth impregnated with gasoline, or a scorched cloth will serve.

In an emergency, if you have not equipped yourself with matches, or have not taken care of them, you might with difficulty strike a light with stone and steel. This requires patience, good lungs, and good kindling. You might also use a burning glass, taken from a gun sight or photographic lens, concentrating the rays of the sun, and gun powder, which can be ignited by a number of methods. Open a cartridge and use the powder. But there is little excuse for not having matches in a water-proof box.

2. Importance of Fuel Economy. Kindling is especially important. Recover unconsumed kindling immediately the fire is started. Keep the wood together in a compact fire, without air spaces.

Do not make a practice of trying to warm yourself with a fire. In really cold weather, the heat is not felt more than a foot or two away; so that one side of you is hot, and your clothing scorches, while the other side is still frozen. Hoard your fuel for cooking. In case of a threatened food shortage, burn nothing that can be eaten, such as animal fat.

3. Water

There is water, water, everywhere, and practically all of it fit to drink. Even if you come down on or near sea ice, you can use it if it is more than a year old. The salt crystallizes out.

Ordinarily you need not worry about polluted water in winter. Typhoid occurs occasionally in the north, but you are not likely to be forced down near any dwelling, and besides the snow certainly has not been contaminated.

For cooking and drinking, melt ice rather than snow. First, it is more concentrated; you get more for the heat expended. Second, unless you keep pressing snow down into the receptacle, the bottom layer will melt, then be burned off, while the top of the snow will not melt; your boiler may burn through.

Do not gulp snow if it is very cold, or if your body is cold. It lowers body temperature, and may cause cramps or thirst. Take snow in small bits, and if the temperature is not too cold, warm it up in the hands before swallowing it.

4. Cooking: Food must be thawed before it can be cooked. Newcomers to the North are usually amazed at how difficult it is to thaw frozen food, or even to melt ice. Use "waste heat" to thaw food, by keeping the food suspended over the fire from the very beginning. While making tea, while melting snow or ice, while heating anything, always have food hanging right over the fire.

Undercook, rather than overcook. You save heat, and you save vitamins. If you possibly can, eat the food raw. In fact, it seems true that some animal food, such as bear meat, becomes tougher and stringier with cooking. Boiling food is better than baking or frying it. Use cooking water to drink, unless the cooking has been necessary to remove harmful substances, as from native plants.

5. Foods: a. Rations: We can assume that your party is equipped with some supply of emergency rations. No plane takes off these days in northern operations without a couple of days' full rations. These can normally be stretched; groups of men, doing some traveling, found that they did not consume a full set of three packages of "K" ration per day; and a fairly quiet existence in or around the crashed plane will require less food than would normal operations. Start being stingy with food immediately. And try to keep warm; your body will thus consume less of its stored-up fat in the effort to keep warm internally.

b. Animal Food: You had better start thinking immediately of adding to your prepared rations. Any animal which can be caught is edible, with the exceptions of polar bear's liver, some salt water mussels, and possibly fresh whale meat. Patience and some ingenuity are necessary in the hunting of some animals, but the alert hunter is likely to get results.

Two important staples of life in the north are the seal and the caribou, for both food and clothing. With the .22 cal.-.410 combination gun in the emergency kit, firing at short range is necessary for results. There is the danger in shooting seals in or near the water that the bodies will sink. It is wise to have a harpoon handy, or choose a victim some distance from the water. Aim for head, neck, or shoulders. Seals are likely to sun themselves on sand bars at a river mouth in summer, and on the edge of ice floes in winter. On the pack in winter look for the holes they have to make in the ice to breathe through. You can learn to eat the meat, and even the blubber, raw. The seal does not have to be skinned immediately, since its flesh, unlike other animals, does not freeze hard immediately.

The caribou can be eaten raw. Their broad tracks are easily recognizable, and they may be found at some time all over the northland. Aim for shoulder or neck, rather than the head, which is a difficult target. At nightfall there is a tendency for the animals to bunch up, and there is a greater chance then of getting more than one animal.

Polar bears are pretty dangerous to play with. They have great vitality, and are fine swimmers. They are seldom found inland. Since the polar's main food is seal, caught on solid ice or on shore, it might be an idea to hunt a victim-seal's carcass, as the white foxes do, rather than the bear itself. There are several other kinds of bears in the north--brown bears, grizzlies, and, in the wooded country, the small black bear. Most bears, except the male and unpregnant female polar, hibernate during the winter.

Rabbits can be shot or caught with snares, but should not be solely depended on for food, because of the leanness of their bodies. Ptarmigan can be caught easily by hand or snare, or hit with sling shots. Gulls are so hungry all the time that they are easy to catch. Do not consider it a miracle if a hungry one lights on your head.

c. Plant Food. If the ground is snow-covered, you must scrape down to the ground. Lichens (reindeer lichen and rock tripe) are the best and most abundant sources of plant food. They should be soaked in water and, if possible, boiled. Vitamins can be found in the buds of birch, willow, or other woody plants which project above the snow, or can be found by digging.

In general, then, do not assume that there is no life in the frozen north. Keep your eyes open, and know where to search, and you may well find enough to make the difference to you between starvation and subsistence.

C. Some Hints on Health

The best advice is, do not worry about your health. Naturally, you are likely to lose weight when living in emergency conditions on emergency rations. And do not start worrying now about the problem of defecation in a temperature of forty below. You will not have the natural urge as frequently as you would at a home base. Besides, you will be eating less food, and require less elimination. And there is no medical certainty that your body requires an elimination every day for health. Men have gone for a week in the arctic without a movement, without any ill results. Your urine will be thicker, and perhaps deeper colored than ordinary. It may even develop a pungent smell, after a couple of days of emergency rations. Do not let this worry you. You will run out of food, or be rescued, long before there is likely to be the least danger from this source. The game of seeking variety in your rations and stretching them will occupy your mind; do not let your spirit down. Similarly with vitamins. Do not worry about them. Your normal ration will contain enough to keep you going, and even if it does not, it will be weeks before vitamin lack begins to have any visible effect.

Air out your clothing as much as you can. Try not to wear the same clothing day and night. If you change quickly in a sheltered spot, you need not worry about your body freezing. Cleanliness helps maintain warmth in your clothing.

Many men have acquired a bit of dangerous small knowledge about "lung frosting". They may fear that moving in extreme cold may cause an inflammation of the lungs. It should be said now that there is no clear record in medical circles of the north of any such trouble experienced by human beings. It is true that animals, such as horses and dogs, have died from a condition that would fit the term "frosting of the lungs", but even in animals this can be avoided. It is agreed that the important precaution, for both men and beasts, is to start work slowly, so that there will be no panting and rapid breathing. Eskimos are careful to hold their dogs back on beginning travel after a rest, despite the animals' eagerness to be off. Too great exertion too soon will cause trouble.

Human beings can develop a pain in the chest region after great exertion in the cold, and trachial-bronchial infection is possible. But immediate frosting of the lungs is not likely. To avoid all such trouble, go easy at first.

Another general notion is that dwellers in the north are more susceptible to tuberculosis. This has received no support from the experience of Army physicians in the north.

In general there is less likelihood of infection in the north. Tetanus and gas gangrene from infected earth are rare. Colds occur with only slightly greater frequency in northern army camps than those elsewhere, usually because of crowded conditions and difficulty of ventilation. Typhoid exists, as all over the world, from infected water, but in no greater proportion.

"Sun-blindness" is not really blindness, but an intense pain in the eyeballs, resulting from glare, or even the continual attempt to adjust the eyeball to terrain which fails to offer contrast and shadow. Thus the ailment can be developed on days when the sun is hidden by haze. The remedy, of course, is rest in darkness; the prevention is an ordinary pair of sun goggles, without metal, and shielded on the sides. The lenses must be fairly dark for adequate protection. Amber or orange colored glasses are approved by some authorities because they afford greater perception of contrast, as of ground levels.

These glasses are more useful on bright, hazy days of diffused light, than on days of direct sunlight. There are no shadows, and orientation is difficult, causing eyestrain. The sage-green lens, used by the Army, affords maximum protection against harmful radiation with minimum color distortion, and is considered best for general conditions and bright sunlight.

It is important to keep the face as free of hair as possible. Your breath will condense on your moustache or your beard, and your skin might freeze. Another symptom which might have an effect on beard-freezing is the normal tendency of the nose to drip freely.

V. TRAVEL

Although traveling is contrary to the advice of every authority on arctic winter conditions, it may be necessary under certain conditions. The plane may have fallen on shore ice which is likely to break up; one of the men of the crew is badly hurt, and it seems advisable to have others in the party attempt to bring help sooner than it might otherwise come; food has been exhausted, and hunting is bad; you might be pretty sure of your direction, and believe that you can make your goal handily with the equipment on hand.

A. Go Easy

If you decide to take off cross country, keep one warning in mind: do not try to fight your environment. When you feel tired, rest; if you cannot see where you are going, stop; if the air gets very cold, and there is a wind that is hard to fight, dig into the snow, and wait for better weather. You are much more likely to freeze when your vitality is

down. The only time it is dangerous to sleep in the snow is when you are so tired that your body cannot respond to the warning of cold. Ordinarily, if you sleep in the snow, your body will feel the cold before it becomes dangerous. Then you can move about, and exercise moderately to warm up.

As you start the trip, do not move too fast. Warm up gradually, so that you do not sweat. Loosen clothing as your body warms. Then, after you have been traveling for a while and your body gets somewhat tired, close up your clothing, and put more on.

Before starting, arrange an emergency bag, with extra mittens, parka, socks, underwear, rations. This should go on top of a sled. It is wise to make a sled, if you hope to take along change of clothing, sleeping bag, fuel. The sled can be made of boughs, strips of metal, made flat to glide over the snow, after an application of ice to the runners.

Part of the equipment to be taken along on a trip should be a number of rolled-up patches of burlap soaked in kerosene or oil, to be used for kindling to start fires. This will save time in fire-making.

B. Precautions and Techniques

Certain precautions are necessary in pitching camp at night. Do not settle down under a bluff covered with snow. The wind might blow some of the snow down on you, and you will be lucky if you escape unsmothered. Or the wind, coming from the opposite direction, might drift snow up against the bluff, and over you. Do not pitch camp on thin ice too far from shore. Ice has a way of breaking off.

If you have to ford a stream or a body of shallow water, prepare your non-waterproof footgear such as mukluks by dipping them quickly in the water, then withdrawing them, so that a thin film of ice develops as the water freezes. Dip repeatedly, so that the film gets thicker. This will prevent water from penetrating into your boots and socks while you are fording. When you get to the other side, you can try to chip off the ice, and dry out the boots.

It is important to know your direction at all times. Depend not only on your compass. If the wind sets in and you have to hole up, or even if you camp for the night, be careful to note from which direction the wind is coming. If you are unsure of the route to follow when you start again, aim to move so that the wind hits in the same way that it did when you stopped. It is likely not to have veered too much. Or better, observe the ridges of drift snow piled up by the last storm when you camp for the night so that you can take off at the same angle to these ridges.

A general reminder on all northern activities: avoid if possible doing anything alone. Company keeps up spirits; makes preparation of a camp or food easier; and helps observe and treat frostbite.

VI. SURVIVAL IN SUMMER

A. Clothing

Your summer clothing will depend on where you are. You will need some kind of winter clothing available for operations near the coast, or to tide you through a storm. Ordinarily, however, all you need is summer underwear and ordinary prescribed uniforms.

One precaution to flyers is necessary. Those who will be flying over the Aleutians, with their constant fog and haze, will know that the greater portion of their operations will be over water. They will learn quickly that the water warms up not very much in the summer; in August it is hardly ever over 50°F. In flying, therefore, it is necessary to wear heavy clothing, both because of the actual air temperature, and because of the greater protection in case of a force-down on the water. The greatest fear of flyers is immersion in the bitter cold water. Death after about an hour in the water has been reported on several occasions. Heavy clothing will help retain body heat for a longer time until rescue.

B. Insects

The most important point about summer clothing is the need for complete protection against mosquitoes. They are innumerable and ubiquitous. A head net is necessary, to be attached to a wide-brimmed hat that keeps the netting away from the face. A complete bed net is desirable for sleeping, even over a sleeping bag. Insect repellents or fly dopes have been found quite satisfactory. Some formulas, developed for the Army, are good for 4 hours. One device is to soak a handkerchief in the stuff, and rub your face and hands with it periodically. An encouraging news item reports that more and more satisfactory repellents are being discovered continually. Sprays, or an insecticide gas bomb, must be used in an airplane before taking off, and also in a tent or dwelling before going to sleep, or occupying it.

Goggles are necessary not only in winter. They must be worn when on sea ice, glacier or snow-covered surfaces, and they will also be found helpful near the coast or on the water, which throws off a brilliant reflection. Goggles can be improvised if necessary by cutting out a piece of cardboard or wood the size of a lens, and making a narrow slit like a T, to squint through. Ear pieces must be improvised out of string or wood or wire. It is better to have a spare supply of ordinary drug-store goggles.

Shelter in summer is necessary as a protection against insects, light rain and snow, and to provide darkness for better sleeping. Remaining inside a plane will serve the purpose.

C. Food

Food and water are more abundant and easily obtained in this season. There will be pools or streams of water over most of the northern region, because of slow evaporation. Pools of water on sea ice will be fresh, if they are far enough away from salt sea spray.

1. Animal Food: It is obvious that all kinds of animal life will be more easily found in summer. Birds are nesting, mammals are moving around more, and fish are more easily caught.

Birds' eggs are easy to obtain, because of the tendency of some birds in the arctic to nest together in large numbers. Some birds, such as ptarmigan, at this time of year can be caught with the bare hands. Snares and traps are easily constructed.

Fish are abundant near shore, and there is less danger there from breaking ice. Salmon run up streams, most of which are shallow, in the spring, and they and other fish can be caught by building a partial dam of small stones across a stream, leaving a narrow sluice through which they must pass. Here they can be speared or shot.

2. Plant Food: A point definitely in the favor of the northland is that there are no poisonous species of native plants in the treeless section of the arctic. Available foods are of various kinds.

a. Greens: cowslip, dandelion, fireweed, ferns, and many other herbaceous plants can be used for salads.

b. Roots: bistort, wooly lousewort and sweet vetch have edible rootstocks. The kamchatka lily in the Aleutians is also edible.

c. Seaweed: marine algae, like brown seaweed which has been washed ashore, are edible if they are fresh, and not dried or decayed. they must be washed, and are best cooked.

d. Berries: in both arctic and sub-arctic, there are blueberries, bilberries, cloudberries, bearberries; and mountain cranberries are abundant during the short summer, and some can always be found in the spring, preserved from the previous winter. Limited to the sub-arctic are the northern gooseberry, red currant, red raspberry, wild strawberry.

SUMMARY ON ARCTIC SURVIVAL

1. Prepare. Carry as much equipment as possible: kits and spare clothing. Make sure the clothing has insulation, and is ventile and adjustable.

2. Do not take chances on weather. Have clothing ready for sudden change.

3. Outer garments should be windproof.

4. Attach outer handgear to clothing. Mittens are better than gloves.

5. Shoes should not be tight. Wear several layers of socks, and insoles.

6. Sun glasses prevent sun blindness. Have more than one pair.

7. In summer, long garments, tight at wrists and ankles, help foil insects.

8. Do not wear same clothing during day and in sleeping bag.

9. Keep clothing and sleeping bag clean and free from grease. Dirt and grease destroy insulation, help bring chill.

10. Loosen clothing during exertion, to prevent perspiration. Dry body as soon as possible.

11. Watch others' faces for frostbite, and twitch your own face.

12. Do not touch cold metal or ice with bare hands. Stay out of propwash.

13. Do not rub frostbitten parts. Cover with hand or put next to skin of body; bring up temperature slowly.

14. Keep ears covered outdoors. They freeze easily.

15. Keep snow out of shoes. Move toes often. Wear ventile footgear.

16. When traveling, know where you are going; make sure you know how to tell direction with or without compass, by sun and stars.

17. In case of forcedown, stick with plane. Make shelter in snow under wing.

18. Do not despair of finding food. Know the habits of animals, and the likely location of plants. All life is edible.

19. Eat snow in small bits. Do not overcook food.

20. Know how to use smoke, panel, and pyrotechnic signals.

21. Take it easy; do not get yourself into a sweat, and you will last longer.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE DESERT (THREE LECTURES)

D-I LECTURE I—GENERAL CONDITIONS

Prepared by

U.S. THE ARCTIC, DESERT AND TROPIC INFORMATION CENTER

OFFICE OF ASSISTANT CHIEF OF AIR STAFF, INTELLIGENCE

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ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
ARMY AIR FORCES
* * *
School Lectures

THE DESERT

Lecture I:
General Characteristics, Native Life, and Care of Personnel

Introduction

The British film masterpiece, Desert Victory, refers to only one kind of victory in a single desert. The mounting triumph from El Alamein through Tripoli to Tunisia, ending gloriously on the beach at Cape Bon with the round-up of more than 200,000 Axis prisoners, does not mean that we can cross desert operations off our list of things to think about. So long as there is an African army to be supplied; so long as there are African air bases; and indeed, so long as there is a European theatre of operations, with a European expeditionary force, supplied from the Mediterranean, then the African desert will be a factor in our planning.

There are other deserts too, that will enter our military thinking. There are important desert areas in India, in China, in Syria and Palestine, in Australia. Our men are quite likely to find themselves operating from bases in or near one of these deserts. So we might as well start learning now, taking advantage of the hardships endured and lessons learned by our buddies who got there a bit earlier.

First, start unlearning, if necessary. The poet who vowed he would be faithful "til the desert sands grow cold" was not tying himself down for more than a couple of hours--the hot desert gets awfully cold at night, because the dry air and cloudless sky permit rapid loss of heat from the earth.

Another false notion suggested by the poet is that the desert is mainly sand. Only a portion of the desert is covered with sand, and even this has a hard crust. Loose, shifting sand dunes are much rarer than the movies would have us think.

And if you are in the desert and see a mirage--water shimmering, or an enticing oasis--do not tell your sergeant to put you out of your misery. You have not gone crazy with the heat. Mirages are perfectly natural occurrences, resulting from refraction of light by air layers of different density.

But on the whole war news reports have given us fairly realistic pictures of what desert operations are like. Unpleasant, monotonous, dangerous, there can be no denial. But American soldiers can make a

test of their surroundings, and with proper knowledge and care, can live quite successfully and healthfully. At least in African bases we can expect there will be little or no actual combat hardship. But there will still be the climate to understand and master, and the populations to understand and keep friendly.

I. PHYSICAL CHARACTERISTICS

A. General Nature of Deserts

What is a desert? How does it differ from other land areas? What are its fundamental characteristics?

1. Hot Deserts and "Cold Deserts"

The term "desert" is used for those lands which produce insufficient vegetation to support a human population. There are "cold deserts" and "hot deserts". The term "cold desert" is applied to high latitudes, where comparative absence of vegetation is due to the prevailing low temperature and low precipitation. We are not concerned here with this type of land, but with hot deserts which are caused by high temperature and deficient rainfall.

2. Areas and Locations

It is estimated that between one fifth and one seventh of the total land area of the globe is hot desert. Consider the vast expanse of such an area; it would be almost three times the size of the United States and almost 200 times the size of England.

The Sahara desert with its 3½ million square miles, including the Libyan Desert, is by far the largest. The Syrian and Arabian deserts together total about 1,000,000 square miles. The Gobi desert is somewhat smaller, about 600,000 square miles.

3. Much of the hot desert land of the world is located in theatres of operations or in areas likely to be invaded. It is important that you learn as much as you can about deserts. Know where they are situated; know their terrain and climatic characteristics, and become familiar with the animal, plant, and human life that exists on them.

The most important deserts of the world are located as follows:

a. A broad desert belt can be seen on the map of the Northern Hemisphere in an east and north direction across western Africa, Arabia, and northwestern India to the Gobi region of China. This belt is commonly divided into the following regions, although the exact boundaries are hard to define.

1. Sahara Desert (north Africa)
2. Libyan Desert (northeast Africa, including Fayoum and Nubian Deserts)
3. Arabian Desert (southern and central Arabia)
4. Syrian Desert (Syria, Palestine, North Arabia)
5. Iranian Desert (Iran, Irak)
6. Thar Desert (western India)
7. Gobi Desert (China)

b. In the Southern Hemisphere

1. Kalahari Desert (south Africa)
2. Australian Desert (west Australia)
3. Atacama (South America)

B. The Desert Pattern

Regardless of their location, all deserts conform to the same general pattern and exhibit like fundamental characteristics. This should not be interpreted to mean that differences do not exist--that terrain, climate and life forms in the Kalahari Desert are identical with those in the Sahara or the Gobi deserts. There are many local differences, but in general all areas termed "desert" conform to the same environmental pattern. The characteristics of this pattern are as follows:

1. Lack of Water

The almost complete absence of water in any form (rivers, lakes, rainfall, snow, etc.) is characteristic of all hot deserts. Deserts are waste lands for want of it. They support but little animal life, plant life, and human life. Give a desert plenty of water on receptive soil and it will bloom like the tropics (note the desert oases) and support man and beast in large numbers.

a. Rivers

Although there are some rivers in deserts (e. g., the Nile of northern Africa and the Tigris and Euphrates of southwest Asia), a further fundamental characteristic of a desert area is that most river beds carry water only for short periods. There are stream beds (called wadis in Africa, arroyos in the American Southwest), which are dry most of the year. They are watersheds which collect surface water draining off rolling and mountainous terrain. Following a heavy fall of rain, the wadi becomes a raging torrent. For this reason, if you set up camp in a wadi or dry stream bed, be ready to make a quick escape after a rain. In its flow across sun scorched land, the water in a wadi usually dries up or goes underground before it reaches oceanic water, or a large permanent river.

b. Rain and Snow

The annual rainfall in deserts is less than 5 inches per year. Some sections of the Libyan, Saharan, and Syrian deserts have less than 2 inches, most of it coming during the winter months. The deeper one goes into the Sahara the less the rainfall. Much of the rain that falls is in the form of infrequent heavy showers. This type of rainfall results in flash-floods and raging wadis. Certain sections of the Sahara and Libyan deserts are so dry that even the heaviest rain amounts to less than half an inch.

The coastal and plateau areas of North Africa which border the Sahara and Libyan deserts are more humid. The moister parts of the

coast receive as much as 40 inches of rain annually, the drier parts less than 20 inches. The city Algiers receives about 27 inches; Bone, 29 inches; Tunis, 16 inches; Djidjelli, 45 inches; Dakar, 23; Marrakech, 13; and Alexandria, Baghdad, and Teheran (the latter in Asia) between 8 and 10.

Snowfall is absent in the desert except in mountainous sections where the elevation is more than 4,000 feet. The Gobi desert, because of its high altitude and latitude, experiences considerable snow during the winter months. The Atlas mountains which fringe the northern parts of the Sahara, in Algeria and Tunisia, are snow-capped above 7,000 feet from December to March.

The relatively heavy precipitation (rain and snow) encountered along the coastal regions of Algeria, Tunisia and Libya may seriously affect air operations. In late fall landing strips and natural-surfaced airfields turn into treacherous bogs and quagmires. Likewise, in the desert the dust turns to mud during rains, and aircraft frequently bog down.

The relative low humidity over desert areas results in excellent visibility when the air is free of dust and sand. Visibility is best during the summer, when humidity is lowest.

2. Variable Physiography

Deserts are not everywhere flat as a table and composed of vast expanses of sand. Nor is the desert a rolling country of sand dunes as depicted by Hollywood. Desert soil is composed chiefly of residual soil, known as doby and caliche, with rocky hummocks and here and there expanses of sand dunes, mud flats, and salt flats.

Desert altitudes range from sea level to 5000 feet, and the land is often mountainous and rough. This is particularly true in Morocco, Northern Algeria, and Northern Tunisia. Rugged hills are common in the Libyan and Arabian deserts. Yet there are wide stretches of fairly level land in all deserts, land that is suitable for air operations. It must be remembered, however, that the hard crust, once broken or disturbed, creates a serious sand and dust problem.

The following descriptions briefly cover the most important terrain features of one desert area--that extending from Morocco to Egypt:

a. Morocco, Algeria, Upper Tunisia

1. The Atlas Mountains (13,611 feet maximum elevation) cover about one-half of the country. Beginning in western Morocco they have their terminus in northern Tunisia. The rugged Ahaggar Massif guards the southern approaches to Algeria. A plateau of about 3000 feet elevation, out of which the mountain ranges rise, extends in places to the Mediterranean coast. This produces a coastline which is bold and rocky with cliffs rising sheer from the sea.

2. The Sahara Desert begins on the south edge of the Atlas range, about 100-200 miles inland from the Mediterranean, and covers all

of southern Algeria and portions of Morocco. Salt pans (chotts) and mud flats, which when hard can be used as emergency landing fields, dot the desert and plateau tableland. One salt pan may cover several hundred square miles. During the rainy season they are impassable. Planes should never attempt to land on them, wet or dry. They may be swamp under a salt crust.

b. Lower Tunisia, Libya and Egypt

1. This entire area may be said to conform to the layman's idea of what a desert looks like. It is a land containing little or nothing of use to man. Some of it is mountainous and some of it is flat. South of the mountains in Tunisia lies an area of sand dunes which gives way to an inland plateau of 500 feet elevation. Between the dunes and the plateau is an area of great salt pans.

2. The coastal plain of Libya varies in width from 1-40 miles and is the only area, except for a few oases, that contains enough water to sustain human habitation.

South of this narrow coastal strip is the Libyan Desert, an area which for the most part is devoid of water, and has large seas of barren shifting sands and boulder-strewn regions. Chotts (salt pans) are scattered widely and most frequently near the sea coast where rainfall is heaviest. The Tibesti Mountains (10,332 feet maximum) contribute the only major peaks in Libya and mark the southern boundary and the south limit of the desert.

3. Egypt is largely flat desert country broken only by the wide alluvial plain formed by the Nile River and its delta. The flat Libyan plateau lies to the west while to the east, across the Red Sea, are the rugged hills of the Arabian desert, some of which rise to an elevation of 7,500 feet.

3. Temperatures: High with Extreme Range

a. Remember that when you go into the desert you are going into an area that gets hotter than any place you have yet experienced. But because it is a dry heat you may not feel it nearly so much as the summer heat of Florida. The desert loses its heat at night; the low humidity is an inadequate insulator. Deserts get cold at night and you will experience changes of 30-50 degrees from day temperatures. You will suffer from the cold unless you have adequate clothing and blankets.

b. Temperatures vary with the altitude, the month of the year, and the time of the day. Areas of high altitude have a lower temperature than do low areas. It is much hotter in summer than in winter, and colder at night than during the day.

c. In the Saharan and Libyan Deserts you will experience summer day air temperatures of 100-127°F. At night it will drop to 73-78°F. The highest recorded air temperature in the Sahara is 133°F. Soil temperatures are even higher and your feet and body will feel scorched on contact with 175°F. of soil heat. Winter temperatures are 73-78°F. during the day and drop to 41-50°F. during the night.

d. Temperatures are lower on the plateau and along the coast of North Africa than in the true desert. A typical summer day ranges between 70° and 95°F. Freezing temperatures occur but are not common.

e. The weather of the North African area may be divided into the same four seasons that we are accustomed to, with the same months in each season.

f. Some deserts are extremely cold during the winter months. The Gobi, because of its more northern latitude, has temperatures as low as 14-20°F. The summer temperature is 80-90°F, but can go higher.

4. Sandstorms and Strong Winds

In all deserts sandstorms occur periodically and without warning, and winds of cyclonic velocity produce considerable turbulence that may extend up to 7,000 feet. The Sirocco, a hot, dry, and dusty southwind, blows with considerable force in Morocco, Algeria and Tunisia. It may last for just a few hours or for days; it is least common in winter, and more prevalent in the east of the area than the west. In Libya and Egypt winds similar to the Sirocco are found. Called the "Simooms" (Libya) and "Haboobs" (Egypt) they are hot, turbulent, and carry clouds of fine dust and sand. They are most active during the summer.

5. Scarcity of Animal and Plant Life

Where there is no water there can be little or no life. It is only in the regions where waterholes exist or where the rainfall is above average that life forms are found. Animals are limited to gazelles (a form of antelope), jackals, rats, lizards, and insects.

Except in the oases the only vegetation in the Saharan and Libyan Deserts is low-growing shrub and camel grass. Shrub palm and grasslands border the desert tableland, and evergreen brush predominates along the coastal plain and in the valleys. Forests are found on the windward slopes of the mountains.

6. Low Density of Population

Five persons per square mile would be a generous figure for population in deserts over the world. There are large areas of the Saharan and Libyan Deserts with fewer than two, or entirely devoid of human life—the reason being lack of water. The population of the Saharan and Libyan Deserts is less than one-tenth that of England, yet the land area is sixty times larger.

Desert people are widely dispersed in the form of loosely organized tribal groups. They are hunters and food-gatherers, and roam thousands of square miles of desert land in search of food. Some peoples drive their flocks of sheep and goats with them. All desert peoples are nomadic and have a simple material culture. The Bedouins of Arabia, the Tuareg of the Sahara, the Bushmen of the Kalahari Desert and the Mongols of the Gobi Desert are good examples of desert nomads. Nomads traverse the desert by means of trails and caravan routes. Six main caravan routes cross the Sahara. There are several caravan routes in the Gobi and Arabian Deserts that have been in use for thousands of years.

Permanent villages with a fixed and ready source of food (i.e. agriculture in some form) are found only at oases. Examples in the Sahara are Biskra, Touggourt and Insalah. Also, springs, irrigation channels, and wells—wherever there is water—are other centers of population.

7. Mirages

The optical illusions called mirages are sometimes caused by two sets of light rays, one convex and one concave, which reflect the sky's image making it appear as a sheet of water. Rocks and trees can also be reflected. Similar mirages may be seen over smooth surfaces, such as tarred roads on calm hot days.

It is most important not to be fooled by these mirages into expecting water, or being led off the course.

8. The Desert and Its Relation to Air Operations

The remarks and observations which follow pertain only to the plateau and desert areas of Morocco, Algeria, Tunisia, Libya and Egypt.

a. The coastal areas of Morocco, Algeria and Tunisia offer no serious hindrances to air operations. Visibility is good though over mountainous regions flight may be hampered by heavy cloud formations and bumpy air.

b. Warm fronts of cyclones may bring fog, dust storms, gales, and low-level icing. The rainy season turns airfields and landing strips into mud, a factor which seriously deters air operations.

c. Spring and early fall are the seasons best adapted for air activity in the coastal areas of Morocco, Algeria and Tunisia.

d. The flying problems are different in the inland desert areas, In summer, great heat, dust and bumpiness will present trying conditions. Landings on untreated surfaces which throw up huge clouds of dust will be a major problem of maintenance and operations (See Lecture D-II). Visibility is generally good but works a tactical handicap on low-ceilinged aircraft.

On the basis of tactical experience, spring and fall are the best seasons for the operations of aircraft in the desert section of lower Tunisia and Libya. In the Egyptian area, fall offers the fewest hindrances to air operations.

e. Forced landings in the desert present a series of problems to aircraft personnel. What to avoid in landing the plane, what to do after landing, and how to survive in the desert and problems which must be solved for success in desert warfare. (Note: What you should know and what you should do are covered in Lecture III--Desert Survival.)

II. THE NATIVES OF NORTH AFRICA

From the standpoint of personal advantage, you need the friendship of the peoples of the desert. The more you know about them, the better equipped you are to enlist their cooperation in maintaining yourself. The time may come when their active help will be needed in your fight against the desert and the common enemy, while their animosity can make life difficult.

In the second place, each American soldier is a personal representative of the United States. How well he understands the natives and how well he gets along with them, affects not only himself but his whole outfit. His behavior will give some north Africans their first deep impressions of America and Americans. Each man can help or hinder the present and future relationships between our land and theirs. Every blunder in dealing with the natives is a boost for the Axis.

Treat the natives with respect and dignity. Avoid the narrow attitude of so many people about "foreigners". Remember, you are the foreigner in this case; it is their country you are staying in. It has been their land for several thousand years. They are as proud about their way of life as we are about ours, and more sensitive. Do not demand things, but ask politely for what you need. Be free with your cigarettes, if you need help.

There is another reason, too, why you should know the natives. An intelligent effort to make friends among them, to understand and sympathize with their customs and beliefs, can result in a rich personal experience, one that can never be estimated in narrow terms. You will find that other people's main problems of living are the same as ours, but through thousands of years of living in a different kind of country and with a different background of culture, they have met these problems in different ways. Refrain from judging their ways as better or worse than ours; our standards do not always apply.

In this section we discuss primarily the peoples of North Africa, but much applies to the Moslem inhabitants of other desert areas.

A. The Peoples

1. Age of the People

The past history of the north Africans goes back into the Stone Age. The modern people, undergoing continual mixture, are probably not much different from those who lived there before written history began. Their inheritance has derived from the rich stores of ancient Egypt, Phoenicia, Rome, and Arabia. They have maintained themselves under harsh desert conditions for thousands of years and they are still a rugged and intelligent people.

2. The Races of North Africa

One of the first things that will strike you is the variety of physical appearance. Traits range from dark skins, black eyes, and kinky

hair to blue eyes, blond hair, and fair complexion. Between these extremes are all manner of mixtures and combinations, though the majority tend toward dark coloring. This is to be expected from their location, between the European whites and the tropical African blacks. The north Africans are the racial link between these two great areas; they are just a step removed from the dark-complexioned Latins of southern Spain, France, and Italy. This original population is often called Berber. The Berbers vary a great deal, not only in physical appearance, but in customs and habits as well.

3. The Islamic Influence

There is, however, one great common bond shared by most north Africans: the Mohammedan faith, or, more correctly, Islam. More than a thousand years ago, Arabs began entering Africa from southwestern Asia and gradually they pushed across the African continent. The Arabs were Moslems, or Mohammedans, as we say, and they were enthusiastic missionaries. Today the religion of Islam has spread west as far as Morocco, and the main north African language is Arabic. This Arabian influence is weaker in the west; in Morocco the Berber speech and culture are still dominant.

4. The Arab and the Berber

The Arabs and Berbers live different kinds of lives. You are more likely to meet the Arab and the Arabized Berber element in the desert and towns, but something should be known about the Berber as well. The Berber is first of all a farmer, deeply rooted to his native soil. If he leaves his land for business or other necessity, he is glad to return. His general outlook is democratic and most of his leaders are elected, though individual strong men may acquire prestige through raiding and war. The Arab and the Arabized Berber, on the other hand, are no farmers. They roam about the desert with their herds. Their society is primarily aristocratic, and they are ruled by leaders who inherit their offices. Unlike the more tolerant Berber, the Arab tends to disdain other religious sects of Islam, and for the non-Islam like yourself, he often feels contempt. But the Arab will not show his feelings of superiority; he is too courteous and hospitable. You will not have any trouble with him if you keep in mind that the Moslem is sensitive and proud of his way of life. Respect this attitude as you would expect your own serious ideals to be respected.

B. Rules and Customs

1. Stick to the Native Rules

Learn to show respect for the religious and social practices of the Arabs and the Arabized Berbers, no matter how odd they may seem; for example, their customs at meal times, and the role played by women in Moslem life. Respect women's privacy and strict modesty. You will run into formalities of social life that seem extremely strange, but stick to the native rules, not only in the cities and towns, but in the open desert as well. And try to appear natural about it.

There are a number of important practical rules that should be learned right away. A great deal more can be learned by personal experience, but find out as much as possible before you start; it will help you get off on the right foot.

2. Rules about Their Religion

The Moslem is very touchy about outsiders going into his holy places. Keep away from mosques and shrines; do not go into one and do not even loiter near one. If you have to pass a mosque just keep on going, and do not spit or smoke while you are passing it; that is a grave insult. Remember that to a Moslem there is no other religion than Islam, so you will do well to avoid discussing the subject. Religious discussions are in this case downright risky. It is the Moslem practice at certain times of the day to stop whatever they may be doing, kneel on the ground, and bow towards Mecca, their holy city. When you see this happen, it will, of course, seem curious, and it may strike you as funny. Never show such curiosity or surprise. Do not stare or smile at such customs, and do not attempt to photograph them.

A particularly sacred period for Moslems is their month of Ramadan. During this interval of twenty-eight days they have nothing to eat, drink, or smoke from sunrise to sunset. Never offer any of these forbidden articles to a Moslem during the fast period, except after dark.

3. Rules about their Women

Behave toward Moslem women with extreme care. They are very much secluded, and excessive modesty is demanded of them. Do not try to attract their attention on the street or any other place. Even what you might consider a friendly smile is an offense to their modesty. It is only inviting trouble to talk to them, follow them, or make any kind of a pass. Never enter a Moslem house without knocking, and if a woman comes to the door, do not go in until she has had time to retire. The free and easy American social relationship between men and women is unthinkable among Arabs. It is a scandalous thing for a woman to even speak to a man who is not of the family, even in the home. The women rarely eat or drink with their own men folk, and, on the street it is required that they walk well behind the men. It may be hard to sympathize with such practices, but never show any disapproval--it can only cause trouble. As far as you are concerned the women of respectable Moslem families just do not exist. Do not pay any attention to them, do not discuss them with the men, do not even inquire about them.

4. Rules about Eating

It is not likely, but you may get a chance to eat in a Moslem home. You will probably sit on rugs or mats instead of chairs. And most Arabs eat with their fingers, often out of a common bowl. You will eat with men only because it is the law that women and children eat alone and after the men. Manners require that you repeat the word bis-mil-lah before the meal is begun. Wait until your host starts eating. It is bad manners to cut bread with a knife; it should be broken with the fingers.

Pages 11-12 missing

is held down. But if, through ignorance or carelessness, this evaporative cooling system is abused or neglected, the machine can be seriously damaged or burned out just as surely as any other combustion motor. There are a number of ways in which the motor can be kept humming at maximum efficiency.

1. Food and Body Cooling

First, there is the kind of fuel used in the engine. Foods should be favored that are easily converted into energy and which produce a minimum of waste. Do not clog the motor with slow burning fuel; it is like using low octane gas in a P-51. Sugary types of food are good quick-energy producers: starchy things, hard candy such as lemon drops and the like. Foods highly charged with vitamin B are more needed in hot deserts, e.g. liver, whole wheat and green vegetables. All kinds of fruit juices too, are good, particularly for their vitamin C content. Regular rations are set up to include these elements. Eat all the rations; do not pick and select.

2. How Clothes can Help

There are a number of helpful hints about clothing that will aid the body cooling apparatus. Remember, cooling is brought about by evaporation of water through sweating. Wear loose clothing. This allows more air movement at the body surfaces, which permits more rapid evaporation; and that means more efficient cooling. So except, perhaps, for a snug-fitting cotton undershirt to absorb perspiration, wear clothes loosely and let the breezes play around your skin. The natives have taught us another trick of desert dress. They wrap themselves in heavy robes and gowns. They have learned that heavier clothes soak up the sweat. This prevents it from being wasted by running off the body, and keeps it near the body surface where it can gradually and evenly cool by evaporation. Clothing also prevents absorption of heat from the sun and the desert floor.

Another habit of desert people can be imitated with profit. They do not hurry or exert themselves unnecessarily. They can move fast enough when they have to, but their ordinary pace is unhurried and deliberate. Physical exertion burns up energy, creates excess body heat and results in water loss through increased sweating. Reserve your energy for the emergency.

B. Sweat and the Salt Balance

In the course of normal active duty on the desert, much perspiring is to be expected; this loss of body moisture may not be apparent because of rapid evaporation in dry air. Sweat is salty, and the role of this salt is important. If too much salt is lost from the blood stream through excessive sweating it can lead to serious trouble. Learn to maintain a proper balance by using more salt. Sprinkle it liberally on food at meal times and make use of the regulation salt tablets; crumpled up, in water between meals.

1. Cramps

When the salt balance in the blood runs too low, muscular cramps may result. They attack the muscles of the legs, arms, belly and chest. They are painful and temporarily disabling. Dizziness, general weakness, and vomiting may go with the cramps. Taking extra salt with drinking water is the best precaution against heat cramps, especially when you are sweating freely. To treat an attack, rest in the shade and drink three or four canteens of water in the next ten or twelve hours. Use two salt tablets to each canteen full.

2. Heat Exhaustion

A more serious result of too little salt in the blood is heat exhaustion. Frequently it comes on very rapidly and it acts like shock. The first signs are nausea, dizziness and weakness. The face turns sickly pale, there is profuse sweating and the pulse weakens. Sometimes the victim faints. The best way to avoid such danger is to avoid unnecessary exertion and keep the salt balance on your side. Treatment of heat exhaustion is the same as for cramps: rest in the shade and water with salt.

C. Heat Stroke

Another serious condition that results when the body thermostat quits is heat stroke. This happens when the cooling system breaks down; it can happen very quickly and with little warning. The first signs are headache and dizziness. The face turns dull red and the skin becomes dry; the eyes stare, breathing is in sharp, irregular gasps, and the pulse pounds. The brain may be affected and the person may become irrational. Vomiting may occur and unconsciousness follows in a few hours. Heat stroke sends the body temperature soaring to 110 and 112 degrees, and the treatment is aimed at bringing the temperature down before the body engine is burned out. The victim should be rested in the shade with his shoulders raised. Remove the outer clothing and soak the body with water. Keep fanning to increase the evaporation. Water with salt tablets may be given when the patient is conscious.

D. Water

Water is not only the life of the desert but also the source of dangers and we need to know more about it.

1. Water Ration

The amount of water necessary for living on the desert depends on the supply, the weather at the time, the kind of work being done and the food being eaten. Three or four quarts of water are a generous desert ration for all purposes: drinking, cooking, and washing. With careful use, this amount per day is sufficient for an indefinite period. Under emergency conditions one quart a day will keep a man at nearly normal efficiency for about five days. A pint a day will just keep you going for several days with the minimum of activity only at night and by lying up in the shade during the day.

2. Water Conservation

Personal habits must be changed to conserve water. Develop efficiency of movement and activity. Learn from the desert folk, human and animal, to avoid the sun when it is high. Work and travel as much as possible in the cooler hours of dusk and dawn. Remember the tips on clothing; wear garments that are not tight, but heavy enough to catch the sweat so it will not pour unused off the body. Drink slowly, in small sips, moistening the mouth.

3. Water Precautions

Never drink water from wells, springs, streams or any other source if it has not been boiled for at least five minutes or chemically purified. Equip yourself with halazone tablets for sterilizing water; they can make water drinkable even if it is muddy or scummy, if you filter it first through a handkerchief or shirt. A couple of drops of iodine to a quart of water are also effective in purifying it. Do not even rinse your mouth with untreated water; a break in the lining of the mouth is an ideal port of entry for thousands of germs.

E. Diseases Carried by Water

The commonest diseases contracted from contaminated water are Dysentery, both bacillary and amebic, and Typhoid Fever. Do not expect complete protection from your typhoid shots. As for dysentery, there is no precaution except avoiding the source of infection; in this case, untreated water. Asiatic Cholera is also conveyed by unclean water, although cholera is rare in the African desert.

Another disease that fresh water can transmit is Schistosomiasis, caused by a parasite that occurs in canals, pools, streams, and lakes. This "bug" can enter the body through any slight break in the skin, or can make its own break. It eventually finds its way to the bladder or rectum where it destroys the lining of those organs with serious effects. Bathing in the sea is to be encouraged but fresh bodies of water carry the danger of this infection. Make sure a pool or stream of water has been certified by the Medical Officer.

F. Foods That Are Unsafe

Dysentery and typhoid fever can also be introduced into the body by raw vegetables and fruits, particularly those that grow directly on or in the soil. Truck gardens in north Africa are commonly irrigated with disease-carrying water or fertilized with polluted human waste. No matter how fresh and tempting they may look, do not eat lettuce, radishes, celery, or any such vegetables, and fruits that grow near the soil, unless they have been cooked or otherwise sterilized. Fruits with thick skins like oranges and lemons are the only kinds that may be eaten raw with relative safety. Avoid melons, which natives fill with water to increase weight, or soak in water to increase their size.

Milk, as well as water, is a common carrier of disease. Typhoid, dysentery, and Malta Fever can all be contracted from raw milk. So never

drink it unless it has been boiled or pasteurized under proper supervision. The fresh milk of the camel or ass is less risky and may be drunk provided the surroundings are clean.

Any food, raw or cooked, that has been allowed to stand around, especially without a cover, is unsafe. Ices, ice cream, pop, cake, any of the many tit-bits that may look tempting at the bazaars are good sources of infection. Keep away from them.

G. Diseases Carried by Insects

In addition to water and food, several kinds of insects are enthusiastic conveyors of diseases. Avoidance and control of these pests is absolutely imperative.

1. Flies

Common flies carry dysentery and typhoid fever and a lively offensive must be maintained against them at all times. Fight them in their favorite breeding places by carefully screening latrines and by digging deep privy pits. Do not let garbage stand around in the open; burn or bury it immediately. The openings of tents, especially those for food or mess, must be kept screened. Keep food containers and dishes covered at all times. And do not spare the insect spray in your quarters and in the mess tent. Flies abound where natives are living, so avoid living near them or, if that is impractical, keep to the windward as much as possible.

2. Mosquitoes

Mosquitoes transmit malaria. Do not let yourself be bitten. The malaria mosquito can be recognized by the way it holds its body nearly perpendicular to the surface on which it sits or bites. These pests are more active around dusk, the early evening hours, and at dawn. The symptoms of malaria are unmistakable. It starts with a bone-rattling chill that seems very much out of place in the hot desert. This is followed by an interval of burning fever. Atabrine or quinine are the standard suppressives and treatments for malaria. They should be used wherever mosquitoes are present. Atabrine should be taken by sedentary workers, one tablet a day, four days a week; by manual workers, one tablet daily. If quinine is used, five grains should be taken each day. Mosquitoes also cause a fever called Dengue. It racks the joints with pain and produces fever and headache.

Do not be lax about mosquito control. They breed in stagnant water, so do not let it accumulate, even in small cans. If you cannot get rid of standing water, pour oil on it. Camp to the windward of oases, ponds, and other places where water may stagnate. Make careful use of mosquito netting over the tent openings and bunk. When you go to bed examine the netting to see that it is securely tucked in around your mattress or blankets. Look to see if there are any mosquitoes inside the net. Use Aerosol spray in your quarters and the Army issue mosquito repellent lotion on your skin. Also dress in protective clothing in areas where mosquitoes are abundant; wear long pants and shirts with full length sleeves.

3. Sand Flies

The desert sand fly can be extremely annoying. It can get through the older, larger-spaced mosquito netting. Fortunately, it is easily killed with spray and can be kept off the skin with insect repellent lotion. Sand flies, aside from their nuisance qualities, can carry Sand Fly Fever, which is not fatal but causes fatigue and is a general time-waster. Another condition called Oriental Sore is carried by the sand fly. This is rare in the African desert, but occurs often in India.

4. Ticks

The desert is also the home of ticks. These are small sucking parasites that bury their heads in the skin and cause infection. They are common in old houses, caves, and are easily picked up when you walk through brush and grass. The greatest dangers from ticks are Relapsing Fever and Typhus. In removing a tick from the skin do not pull or squeeze it out; if you do, it will probably leave its head behind and cause infection. And do not crush it, or the germs it carries may be forced further into the punctured epidermis. It will free itself if you cover it with spit, hold a lighted cigarette near it, or apply a drop or two of alcohol or iodine. If there are ticks around camp examine your skin and clothes when you dress and undress.

5. Lice

Lice are common in any part of the desert where there are permanent communities of people. The body louse is small, about the size of a pin head, and yellowish in color. It lives in the folds of clothing and breeds in the same places. Body lice transmit Typhus and Relapsing Fever. Head lice are different in appearance and not so dangerous. The usual way to acquire lice is through bodily contact with other people, so in native quarters do not get any closer to people than you have to. Keep your person clean and inspect your clothing frequently. If your clothes become lousy, ordinary washing is not enough to get rid of them. Treating clothes with hot steam is usually effective, or they may have to be chemically dealt with. When you are bitten by lice, do not scratch; scratching invites infection.

6. Fleas

Fleas are especially numerous where there are animals; and sheep and goats are an important part of desert people's economy. Most fleas are merely unpleasant pests, but one type, the rat flea, transmits the dread plague. This species is found almost entirely as a parasite of rats in the desert area.

Fleas have also been proved to be the carrier of a form of typhus. So fleas are not just something to joke about. Keep clean!

7. Diseases Carried by Dogs and Cats

Dogs and cats go mad on the desert as anywhere else and the danger of rabies is especially great because there is usually no kind of control for this disease. Contact with these animals is also a source of ring worm.

H. Stings and Bites

1. Wasps and Bees

Like the wasps and bees in America, those of north Africa are not a serious menace to health, but their stings can be very painful and can cause temporary disability. They are present in houses, underbrush, and in holes; water and sweets are particularly attractive to them.

2. Scorpions and Centipedes

Be careful about poking around under stones, in small holes or in dark corners. These are favorite hideouts for scorpions and centipedes. The scorpion looks like a small crab except that his tail curls up and ends in a sharp stinger. Centipedes have long flattened bodies and are equipped with numerous paired legs. The stings of both of these animals are poisonous, but rarely seriously so. The native practice of smearing mud on the sting is effective, or, if you have it, apply ammonia water.

3. Poisonous Snakes

The desert is not thickly infested with poisonous snakes, but they should not be disregarded. Snakes do not like the heat so they are most active when the sun is low. Avoid reaching into holes, cracks, and other dark, shady spots; these are favorite resting places for snakes. As a rule snakes will avoid people and give no trouble unless they are surprised or annoyed. In case of a bite, however, apply a tight bandage or tourniquet immediately above the wound. The snake bite kit has every part needed. Then with a sharp blade, make cross-incisions at each fang mark. Sterilize the knife before using it--holding a match to it will serve. Cut at least a quarter of an inch deep so bleeding will be free. Then apply suction. A heated bottle held with its mouth firmly against the wound will create efficient suction. Sucking with the mouth is safe only if it is certain that the mucus lining of the mouth is unbroken. The tourniquet should be loosened every twenty minutes so that blood circulation is not completely shut off. Medical care should be reached as soon as possible and if the variety of reptile is unknown, try to bring the dead snake with you to help the doctor in his treatment. Alcohol is not only ineffective, but harmful, in stimulating the distribution of the poison through the body.

I. Diseases from Human Contact

There are two kinds of diseases that are commonly acquired by contact with other human beings: venereal infections and ring worm.

1. Venereal Diseases

The danger of venereal infection in north Africa from prostitutes is extreme. The profession is little controlled and exposure without adequate precaution is most hazardous. The commonest types are syphilis, gonorrhea and lymphogranuloma (this last has no effective cure). Avoid contact, or make unfailing use of prophylactics. If you think you have been exposed to infection you will save much grief in the end by reporting immediately to your medical officer.

2. Ring worm

Direct contact with other humans can also cause ring worm infection of the skin. This affliction, which is the work of a microscopic fungus, is partial to the damp areas of the body: under the arms, the groin, and between the toes. Another fungus (epidermophytosis) causes athlete's foot. Keep these parts clean, dry, and powdered to minimize the chances of infection. Direct contact with people is not necessary to acquire skin fungus.

J. On Morale and Recreation

Finally, if the camp is more or less permanent, the matter of recreation should be considered. Necessity will usually demand that the camp units be dispersed, so each unit will become a sort of social and recreational center. It is important to keep occupied during a good part of leisure hours. There is always opportunity for creative activity about camp: camouflage, dummy installations, repairs, etc. Each dispersed unit can have its own PX and canteen, the center of social activity. The promotion of games and sports, and organized music should be encouraged. There are many and diverse observations and hobbies to be developed and shared in the desert: the natives, the wild life, plants, minerals. Inter-canteen activities will add to the pleasure of relaxation. Rivalry between different units in sports, games and other projects will keep men interested. Effort and thought in this direction will pay big returns in physical and mental well being.

K. Summary of Rules on Desert Personal Care

Here in summary, are some general directions for personal care:

1. Avoid the hot sun as much as possible. Wear a hat in the daytime. Acquire a tan, but do it gradually.

2. Protect the eyes from irritation in the sun and dusty air. Wear goggles or sun glasses.

3. Use skin powder to prevent prickly heat.

4. Watch your feet. Blisters and athlete's foot can be serious. Keep your feet clean, dry, and powdered.

5. Attend to every minor cut, scratch or other break in the skin. Use soap, iodine, or some other antiseptic and cover with gauze.

6. Keep under cover in dust storms or, if you cannot, cover your mouth and nose with a respirator or a cloth.

7. Wear clothes comfortably loose and fairly heavy. Remember that temperature drops suddenly at night in the desert.

8. When flying in the desert, take along clothes that are comfortable to walk in. Keep check on your emergency kit.

9. Use long clothes in mosquito areas. Wool socks are better than light cotton. High shoes are better than low ones.

10. Carry a neck cloth, and another to protect your nose and mouth when you go out any distance.

11. Change and wash your underwear and socks as often as possible.

Here are some important points on shelter:

1. In locating camp, check the prevailing wind and keep out of the path of dust raised by field installations. Locate the kitchen to the windward of the latrine,

2. Disperse the tents widely. See that they are well anchored and adequately camouflaged.

3. Before setting up tents, clean the ground surface of brush, stones, debris of all kinds. Avoid camping near native communities.

4. Use screen and netting over tent openings. Spray tents liberally and often;double these precautions for the mess tent.

5. Do not let refuse accumulate. Burn or bury garbage often.

6. Locate latrine at least 100 yards from camp, at the lowest drainage point. Carefully observe rules of fly control.

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PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

D-II. THE DESERT (THREE LECTURES)

LECTURE II—MAINTENANCE, OPERATIONS, AND CAMOUFLAGE

Prepared by

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ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
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School Lectures

The Desert

Lecture II
Maintenance, Operations, and Camouflage

I. MAINTENANCE

A. Introduction

The desert can be a greater destroyer of your aircraft, your armament, your equipment and your supplies than the enemy himself. Sand and heat are your foes. Get to understand their effect on your equipment. Guard against their attack. It takes eternal vigilance, endless inspection, back-breaking effort to keep your aircraft serviceable for combat. Look after your equipment and it will look after you. Learn the lessons of desert maintenance early. Your existence in the desert depends on it.

The history of aircraft maintenance in the desert is the story of an endless fight against sand. Sand is the foremost foe of your equipment--not only the sand on the terrain, but the dust found in suspension in the air. Wherever the hard crust of the desert has been broken, there is dirty work afoot. There is the deadly scratching, gouging action of quartz-hard grains and pebbles, and the terrific abrasive qualities of dust with the fine consistency of talcum powder.

You cannot avoid the sand and dust. It gets into everything--into engines, instruments, moving parts. "Every time an airplane takes off it creates its own sandstorm. Every minute an airplane is in the air it is reaming out its own cylinder walls, ruining valves and, in fact, tearing down every moving part just as surely as if a saboteur had sprinkled emery dust liberally throughout the engine." The life of an airplane and its parts is unbelievably short once you let sand and dust get the upper hand.

Remember that the abrasive power of sand depends on the size, shape and hardness of the particles. The smaller the grains, and the more angular and sharp-edged they are, the more damage they do. Grains between .2 and 0.02 mm. are sub-angular, having both round and sharp edges. Deadliest of all are the grains smaller then 0.02 mm., which are entirely angular and sharp-edged. Remember that a wind of 20 m.p.h. (higher velocities are common in the desert) is capable of moving grains up to .2m. Remember that dust clouds may be found at altitudes as high as 10,000 feet, and that every cubic yard of air drawn through the intake includes its quota of microscopically fine, abrasive sand. You cannot avoid the sand and dust, but you can win your fight against it by

constant vigilance, by observing some simple rules, by hard work and ceaseless inspection. Get to be sand-conscious. Fight it. You can start by observing these general rules:

B. General Maintenance Rules

1. Locate your maintenance sites on hard standings whenever possible, or on terrain where fine sand grains of high quartz content are at a minimum. The dispersed character of desert operations gives you plenty of location choice. Take advantage of all shielding topographical features.

2. If you can, locate your maintenance site to the windward of abrasive, loose sand areas. Consider carefully the direction of prevailing winds and avoid location in the path of blown sand resulting from the breaking of the desert crust or its disturbance by other installations on the field.

3. When conditions permit, improvise some sort of shelter which will minimize sand interference with servicing. A canvas lean-to, a half-tent, an improvised nose hangar, or a sand-break around the airplane, placed to windward, will prove effective. Small tents, erected on hard clean ground, should be provided for the purpose of cleaning parts under relatively sand-free conditions.

4. Keep the maintenance site clean of sand and dust.

5. During violent sand and dust storms, delay repairs and service (if there is no combat emergency) until the storm abates. Do only such work as cannot be injured by dust or sand.

6. These general rules cover conditions peculiar to desert maintenance. Follow rigidly the detailed instructions in your Maintenance Handbooks for normal servicing.

C. Vigilance Against Abrasives

Remember that good maintenance on the desert calls for eternal vigilance against the abrasive, destructive presence of sand and dust. The desert may be a tactician's paradise but it is a maintenance man's hell. You can lessen your burden by remembering, by observing these further points:

1. The most injurious action of sand and dust results from its adherence to oil-bearing surfaces. When mixed with oil, desert dust is an efficient grinding agent. Guard against it constantly, especially where it attacks close-fitting parts or parts that work against friction. Clean, inspect, and lubricate regularly, frequently, continuously. This is a must.

2. Some surfaces must be lubricated and those surfaces should be cleaned of sand and dust, inspected and re-lubricated (lightly) much more frequently than in non-desert operations. Many surfaces (normally lubricated in non-desert areas) can be best operated dry in the desert,

but they should be cleaned of sand and dust and inspected as frequently as possible. Keep cleaning, keep inspecting--it is your responsibility.

3. Lubricate sparingly and only where absolutely necessary. Sacrifice lubrication rather than risk the grinding, abrasive action of sand and dust.

4. On landing, immediately the engine ceases to fire, seal all engine and gun openings with dust-proof plugs and covers provided for the purpose. (There should always be two sets, one stored in the airplane, the other available for immediate application on the ground.) Keep all seals on while the aircraft is on the ground. After servicing, replace seals immediately. This should become an automatic habit and second-nature with you.

5. Do not lay tools or parts on the desert ground. Every article, large or small, is either lost or damaged or stolen when placed on the ground in the desert. If you must lay tools or parts on the ground, place them on a strip of clean canvas or in a clean receptacle.

6. Metal parts that are removed from service or salvaged should be carefully cleaned, covered with grease and either wrapped in burlap or stored in lockers and bins away from sand and dust.

D. Care of Tools

Tools are priceless possessions in the desert. Give them your best care. Observe these rules--they will make your job easier:

1. Protect your tools against corrosion and damage. Clean them often. Do not use sand-incrusted tools on aircraft. Wrap infrequently-used tools in burlap. Keep them in lockers in a sand-free place whenever possible.

2. Paint an identifying mark on your tools. It will make them easier to find. Mark your tools permanently. Give each tool-kit an alphabetical mark and each tool a serial number in that kit. It will prevent arguments and time wasted.

3. Keep your tool lockers orderly. Keep each tool in its place. It will help you to locate instantly the tool you need. It will also help you keep an easy check and inventory.

E. Working Precautions

Certain precautions should be observed when doing maintenance work under conditions of desert heat. While the heat is disagreeable and you will experience considerable discomfort, you will not meet any really tough problems if you know what you are up against. Here are some important "heat facts" to keep in mind:

1. Structural surface temperatures are dependent upon the heating effect of the sun and whatever cooling effect of the wind there may exist. Low-velocity wind, or absence of wind, will result in skin temperatures 1.4 to 1.5 times free air temperatures, which may run over

130°F. Improvised cover, such as canvas or native matting, will alleviate excessive temperatures. Interior temperatures will generally remain between free air and skin temperatures. Wing empennage or fuselage interiors may rise to 1.4 times free air temperature. Therefore, it is important that lubrication, hydraulic packing equipment be checked. Watch bungee cords, de-icer boots (which should be removed for desert operations), hatch seals, etc., for deterioration. Watch tires for blisters. Check cable control tensions frequently.

2. Metal surfaces become burning hot to the touch. Use mitts or gloves to grasp metal tools or metal surfaces that have been exposed to the sun. Use mats, pads, etc., to protect your knees from hot surfaces on which you may have to work. It is advisable also to wrap cord or heavy tape around the metal handles of tools.

3. Keep the sun out of the cockpit by throwing canvas or matting over it. With windows, coupes and hatches open, interior temperatures may be 10° to 20° lower, but will permit entry of sand and dust. The latter is the greater evil: keep all enclosures closed, unless the wind is calm and the plane is attended by maintenance personnel; under such circumstances ventilation of pilot, bombardier, and navigator cockpits is desirable as a means of guarding against heat warping of delicate instruments.

4. If possible, do all your services and repair during the early morning hours or in late afternoon, evening and night, when heat is less intense.

F. Special Problems

While you will follow your Maintenance Handbooks rigidly for all normal servicing, there are some special facts you will want to know about certain maintenance problems resulting from desert operating conditions. Remember these important facts:

1. Engines

a. When the engine ceases to fire close all engine openings as soon as possible. This includes the plugging of all air intakes, exhaust stacks, breathers, vents, etc. Cover supercharger. Install engine covers (covering the propeller hub and feathering domes and extending back over cowls and exhaust outlets) and point airplane into the wind. Covers should be tight-fitting and tailored to the job. Keep engine covers on engine at all times when it is not being serviced or prepared for operational flights.

b. Air cleaners, oil and gas filters are only as effective as the amount of care you give them. They should be checked, cleaned, and inspected on a rigid schedule. Desert sand and dust quickly choke cleaners and filters. Replace worn-out filters and cleaners immediately. An airplane with neglected, inoperative filters is a grounded airplane; so keep an ample reserve stock of cleaners and filters on hand at all times.

c. Wherever and whenever possible, test your engines on a suitable platform. Revving up on open desert ground results in sand-blasting which pits the prop, fuselage and tail surfaces. Suitable platforms may be improvised as follows: (1) Any hard natural surface, swept free of sand and dust, may be used. (2) Landing mats, if available, and of two or three thicknesses, are ideal. (3) An efficient mat may be constructed by digging a large pit about 6-8 inches deep; fill the pit with cobble-sized (over 4" diameter) or larger stones and rocks, and bring the top of the rock mat about three inches above the ground level; the space between the rocks provides a trap for wind-blown sand and the prop will not suck it up into the blades; after several weeks of use, the rocks can be removed, the pit cleaned out, rocks replaced, and the mat is ready for use again.

d. In spite of all precautions, the prop blades will become pitted on the takeoff and while taxiing. The pits in the prop blades should be very carefully smoothed up with a fine file and emery at frequent intervals. Be sure to remove all the rough burrs and ragged edges around the pits.

e. Check oil consumption carefully - keep a chart. Watch for a sharp rise - it is your first reliable indication of trouble. While the engine can still be operated at decreased efficiency, do not push it. Change the engine in time, so it can fight again another day.

f. Use a high pressure spray gun filled with fluid to clean engines. It works faster and does a better job.

2. Air Frames, Controls, Landing and Auxiliary Gear

a. Clean and inspect regularly, thoroughly, and continuously such moving parts as flaps, control hinges, pulleys, bearings, worn gears, cowl slides, etc. Keep lubrication at an absolute minimum.

b. Try to keep sand out of brake shoes; cover the wheels, oleo struts and retracting screws, while the plane is on the ground. You will also be protecting tires from the action of hot sun and sand.

c. Protect nose sections, cockpits, turrets and other enclosures by fitting them with tight canvas covers. Wind velocity is frequently strong enough to hurl sand and gravel against glass and plastic surfaces with sufficient force to frost and pit them.

d. Protect with soft plugs intercooler air intakes and vents.

e. Keep cleaning rail wheel assemblies and landing gear to prevent corrosive action of salts collected on desert terrain.

f. Sand will collect in all dead air spaces in the wings, fuselage, and tail group. It may gather in such quantities as to seriously change weight distribution and affect the balance and maneuverability of the plane. The salt incrustation, too, is a serious corrosion hazard. Clean the sand out of these dead air spaces. Sand in the cockpit is a menace, too, as it will fly about on takeoff. Clean out this sand. A vacuum cleaner with flexible hose attachment will do the job well.

g. In spite of all protective measures, after each sand "blow" your ship will require a thorough cleaning. Sandstorms penetrate.

h. It is desirable to use a light portable blower to clean sand out of controls which become stiff and hard to move as a result of sand accumulation in crevices.

3. Electrical Equipment Instruments and Accessories

a. Instruments will cause little trouble provided they are properly filtered. Instrument filters should be cleaned thoroughly on a rigid schedule and worn-out filters replaced promptly.

b. Keep pitot heads covered to exclude sand and dust.

c. Gyro instrument venturis should always be kept covered.

4. Armaments

a. Immediately the engine ceases to fire, cover or seal all guns and seal the chutes. Be certain to remove seals from chutes and covers from guns before takeoff. Guns may be left sealed for maximum air speed. The first shot will clear the muzzle.

b. Clean daily all guns, bomb racks and shackles. The sand and dust that gather on their lubricated surfaces may result in disastrous jams. Keep 'em firing!

c. Store all ammunition where dust and sand are at a minimum. When re-arming be especially careful to avoid contact with sand.

d. Do not keep ammunition in the cartridge bins in wings over long periods of time. Dust and sand will collect on the cartridge cases causing jams in the chamber after firing.

e. Bombs should be loaded into bomb bays as quickly as possible to avoid sand entry. Make sure the release catches are free from sand, to insure electrical contact.

G. Refueling

1. Gasoline delivery from cans should be made through a filter funnel that fits snugly into the tank opening. Gasoline delivery from drums calls for quick and efficient muffling with a chamois leather cloth of the point where the hose connection enters the fuel tank. Also use a strainer fitted with a chamois cloth. If gasoline or oil must be poured into the tanks during a sandstorm, take every precaution to exclude sand from the liquids.

2. Extreme care should be taken with high octane fuel at temperatures of 120° or more in the shade. Watch out for sparks. Open the gas drums with bronze or other non-sparking tools. Make sure the plane is grounded, as well as the funnel and nozzle. Make sure there is a conductive connection between the chamois hoop and the funnel, and that the funnel is in constant contact with some metal parts of the ship. The tank rim will do.

3. Do not handle or transfer gas unnecessarily; exposure to air dissipates the lighter fractions and reduces the octane rating. Some pilot may need that extra power.

4. If possible, keep gasoline drums covered and below 102°F. If you can, do your refueling at night.

5. Oil delivery should be directly from the can to the oil tank opening without using an intermediate measuring can or open container.

6. Clean oil and gas tanks periodically, because sand accumulates in the corners, seams and bottoms of the tanks.

II. OPERATIONS

The technique of desert operation presents no serious problem to the competent pilot. There are, however, unusual conditions involving sun, sand, wind, heat and visibility, which are peculiar to the desert and which call for modifications in technique. Observe these desert practices:

A. Preflight

1. Starting and Running Engines

a. Remember that all metal surfaces exposed to the sun are hot to the touch. Wear gloves to prevent burns. (Tape, cord or cloth muffs around control sticks and wheels, throat or hand mikes, etc. are advisable.)

b. Make all possible ground checks before you start the engine. Check all main and auxiliary controls to ensure sand-free and easy movement.

c. Do your own preflight. Never run up engines on the ground any longer than absolutely necessary.

d. Use a platform or hard standing to test engines whenever and wherever possible.

e. Do not run up your engines to windward of other planes, personnel, or ground installations.

2. Taxiing

a. Never taxi planes under their own power when it is possible to tow them.

b. Keep your taxi run as short as possible. Make this a habit.

c. Watch oil, head, and coolant temperatures carefully to avoid overheating.

d. Do not taxi to windward of other planes, personnel, or ground installations. Also, keep your ship out of another's prop wash.

e. When taxiing in formation, keep good intervals. Taxi in echelon up, down, or crosswind.

f. When taxiing in loose sand, hold stick or wheel well back; keep momentum; avoid abrupt turns, but if you must make them, use minimum of differential braking, otherwise wheel will pivot and dig in. Tricycle gear equipment is particularly difficult to taxi in loose sand. The nose wheel has less tendency to trail properly as the depth of the tire sink increases. If the airplane is pivoted on one wheel, the nose wheel will attempt to reverse its position and will burrow so that it cannot move forward, thus severely straining the nose wheel strut and subjecting propellers and engines to damage by sudden stoppage on contact with surface of loose sand. If you must stop, select a relatively hard standing and turn into wind.

g. Intelligent dispersal minimizes taxiing and overheating. Stagger your takeoff assembly and avoid overheating. Let downwind flight start and takeoff first, to prevent blowing sand on other planes.

h. Do not taxi downwind and turn back into a cloud of dust. Approach takeoff point on a wide arc, and if possible, to leeward. It is common practice to take off crosswind. Space is usually not at a premium in the desert.

3. Takeoff

a. Keep well-forward in formation. If you lag, you will catch leader's dust. Spread your "V" as much as practicable. Common practice is to take off in echelon crosswind.

b. Shorten sand takeoffs by obtaining maximum lift as quickly as possible. Fly the plane off the ground. It is easier on the undercarriage and it minimizes ground friction.

c. Watch for sand swirls and whirlwinds. They occur only in the daytime, and they are easy to see. Avoid them.

d. Take off and get your wheels up in a hurry. Start looking! Ordinarily you will have a standing patrol over the field, but every extra pair of eyes helps. Maximum climb and quick assembly should be stressed. Do not get caught at intermediate altitude by a sneak attack.

e. At temperatures of 170° in the sun, air close to the ground is thin and planes with full military load ordinarily require additional takeoff run.

B. Flight

1. Visibility is great and distances are deceptive. Multiply your estimates by three.

2. Remember that the intense, glaring sunlight makes sudden surprise a constant possibility. Keep your eyes open. Develop a swivel neck. Use your rear-vision mirror. Use sunshades and sunglasses. And remember, a wingtip in the sun will enable you to observe the adjacent sky free from glare.

3. High visibility results in increased range of observation, and calls for extreme vigilance. But do not overdo it--if careful scouting convinces you the sky is clear away from the sun, you need not check it as frequently as in other climes. Concentrate on the sun.

4. Execute your attacks with the sun at your back. You will see objects plainly without shadow. Looking into the sun, you will not only be handicapped by the glare and ground reflection, but you will see all objects in shadow. However, remember that camouflaged objects sometimes reveal themselves only by the shadow they cast.

5. Dust often reduces visibility to less than 100 yards, from the ground up to an altitude of 8,000 feet. Such conditions facilitate surprise attacks; control and maneuver are, however, extremely difficult. Similarly, such conditions afford concealment in withdrawal or evasive action. Intelligent use of a moving dust storm will often enable you to deliver a surprise attack on its heels.

6. Visibility is generally good above a dust layer although surface detail is obscured. Note that directly above a dust layer your silhouette stands out prominently, and that, while horizontal visibility is poor, vertical visibility is good.

7. Cloud cover is rare in summer over desert terrain. Do not depend on it.

8. Heat distortion creates deceptive ground impressions. Heat waves emanating from the superheated sand destroy all form for the eye and make recognition difficult.

9. Mirage has an adverse effect on visibility and ground observation. It is seen when facing the sun. Its effect generally is to magnify objects, particularly in their vertical dimension, and to create illusions.

10. Rainstorms of cloud-burst intensity may be encountered; they generally originate from drifting thunderheads and are only rarely of widespread regional extent. They seldom offer any real hazard.

11. Protracted flying close to the ground may run your temperatures dangerously high. Keep this fact in mind.

12. Avoid whirlwinds at any altitude and especially close to the ground. You can see them; stay out of them.

13. Desert combat tactics vary from the normal only insofar as the natural characteristics of the desert emphasize <u>sun</u> and <u>surprise</u>. Desert combat tactics are designed primarily to permit or prevent a surprise attack out of the sun. Altitude, of course, enables you to take full advantage of the sun, to initiate the attack and drive it home with a

performance advantage. Obviously, however, the position of the sun with respect to the horizon determines the relative importance of the altitude advantage.

a. Just remember that what you see won't hurt you. Often an occasional flash in the area of the sun will be all the indication you will have of the enemy's presence. As long as you see and know exactly what your opponent is doing all the time, you can proceed to carry out your assignment, prepared to turn to meet him should he initiate the attack. The man who goes out on a mission and sees nothing or only half of what is going on is destined for a short life in the desert.

b. It should be noted that a properly camouflaged ship over desert terrain provides surprisingly good concealment near the ground from a highflying enemy.

c. In desert combat, it is plane for plane and man for man. You cannot rely on natural protective cover.

d. In low-level attacks, take advantage of sun and surprise. Dawn and dusk are the best time for attack. Fly low and fast. Spread your formation. Take advantage of the disposition of enemy columns, hangars, etc., to avoid AA fire. Take other evasive action. Get away fast.

e. Never repeat an attack once the element of surprise is gone, unless the mission is to silence AA fire.

f. Better conditions for high-level bombardment normally prevail in the desert than in any other terrain. Low-level attack is handicapped by lack of concealed approaches, but is aided by the ability to locate targets from considerable distances.

14. Here are the facts to remember about desert navigation:

a. There are few landmarks on the desert. Those that do exist are easy to identify. Get to know them quickly; appreciate their importance.

b. Your dead-reckoning will require accurate compass courses and time intervals.

c. Make your own additions to your maps; sketch in and identify local features of terrain, combat debris, craters, etc. Such details, if unusual, will help under conditions of reduced visibility.

15. You will encounter sandstorms which will make return to base difficult. Watch for breaks and clear spots and get down through them quickly before they close. Sandstorm areas move. Appraise their direction and speed. Common sense will dictate whether it is best to beat them into your field or to wait them out. Use your ground control and weather organizations intelligently and to the fullest extent possible.

16. Always observe local practice with respect to recognition signals, use of corridors and set-approach patterns to fields. Never

approach a field from out of the sun, but always come in at an established altitude and from a standard direction. AA, whether it be hostile or friendly, is particularly effective in the desert, and due to their exposed position and the ever-present possibility of surprise out of the sun, AA gunners are inordinately sensitive to unidentified planes disregarding local practice on recognition signals.

17. Do not stop looking until landed and dispersed.

C. Landing

1. Heat distortion and mirage may affect depth perception. The tendency will be to level out high. Observation of shadows and other reference points will help counteract these conditions. If any doubt exists, always plan your approach to allow of a power landing, which will minimize the consequences of misjudgment.

2. Avoid sand swirls and whirlwinds when landing. They are encountered only during the day and close to the ground.

3. Cut throttle at earliest practicable moment after clearing the landing area. Do not taxi with engine.

D. Mooring

Sudden violent wind and sandstorms are common in the desert. When not in use, lock controls and moor all planes with equipment provided for the purpose. In tornadic winds, employ wooden 2 x 4 "spoilers" secured to the topside of the aircraft wings, immediately behind and parallel to the leading edges. This will break the airflow and nullify the normal lifting characteristic of the wing.

III. DISPERSION, CAMOUFLAGE, AND PROTECTION

The desert produces a feeling of nakedness. There is little or no natural concealment, and you are always open to easy observation from the air and to surprise attack (assuming, of course, that the enemy is within striking distance). But you can do plenty to minimize the loss or damage of aircraft, equipment and supply, and the danger to personnel. Imagination, ingenuity, and intelligence will play a big part in the success of your desert operations. Learn the lessons of dispersal, camouflage and personal security right from the start. Practice it all the time. Make it a part of everything you do.

A. Dispersion

Dispersion is the simplest and primary means of saving aircraft, vehicles, permanent installations, temporary structures, materiel, and personnel from destruction by air attack in the desert. It not only minimizes loss and damage, but it discourages enemy aerial action by offering insignificant targets. It must be remembered, however, that dispersion lays you open to attack by ground raiding patrols for which the desert offers an excellent "playground". Arrange your dispersal to balance up the two risks:

a. Disperse for protection against attack from the air.
b. Concentrate for defense against ground attack.

Observe these vital rules of dispersal governing aircraft, airdromes, personnel, mobile equipment, buildings, runways, and supplies:

1. Aircraft. Immediately upon landing, get your aircraft well away from field installations and other aircraft.

When airplanes are on the ground they should be dispersed, not in a straight line, but staggered, and 200-300 yards apart to form irregular patterns well away from the runways. It is important that adequate transportation be provided to carry pilots to and from planes. This not only saves time but (a) eliminates the very human tendency of pilots to bunch their planes at the point nearest to the operations tent to avoid excessive walking, and (b) avoids a long run to planes in a "scramble" upon an alert.

2. Airdromes, Runways, and Facilities

(a) In the desert, aircraft should operate from many dispersed airdromes. This is practical, as was shown by the British in Libya, because of extensive open areas and the relative ease of constructing runways.

(b) These airdromes may consist of one or more runways or flight strips depending on wind conditions. The runways should be dispersed or disconnected to avoid forming the geometrical patterns characteristic of peace-time airdromes.

(c) Facilities at the airdrome must be dispersed in suitable camouflaged shelters. Only essential activities, such as operations and engineering, should be permitted near the airdrome. Bivouac areas, messing facilities, and truck dispersal areas should be about two miles or more from the runways.

3. Vehicles

(a) In daylight, vehicles should be dispersed 100-300 yards apart to take advantage of natural cover and to minimize losses. On dark nights without moonlight, distances may be reduced. When traveling on the roads in convoy, vehicles should be spaced at least 100 yards apart.

(b) At command posts, rigid discipline must be maintained. Vehicles must not approach within 300-400 yards of the command posts or similar installations. Do not let tracks give away important installations.

4. Supply Dumps. In the concealment of supply dumps, disperse at least 300 yards apart. Keep reserve stocks of gas and oil in small tins, dispersed and in shallow trenches to avoid bomb blast. It is far safer to disperse 5-gallon tins of gasoline than to risk the complete loss of a single 50-gallon drum.

5. Remember always that dispersal is the best means of protecting aircraft and installations from enemy air attack. At Pearl Harbor and

Hickam Field, large installations, hangars, mess halls, planes, etc., all of which were arranged in an orderly pattern, were knocked out in the first attack. In comparison many airfields in North Africa came through repeated bombings undamaged, as installations were dispersed and had not been spotted.

B. Camouflage

Camouflage is any and every means of hiding or disguising yourself from your enemy; misleading him as to your position, strength, and intention; and confusing him so that he wastes his blows and falls into your ambush.

Do not underestimate the battle importance of camouflage! Your own personal safety, the safety of your men, supplies and equipment, and the successful accomplishment of your mission may be made secure by the common sense application of the ordinary camouflage principles, coupled with a little imagination.

It is not a job for the specialist alone nor is it an affair of ingenious tricks by which conspicuous objects can be made to disappear by magic. It is a vast problem because every single member of the Army contributes to it every day in the normal course of his work and life. Even though the enemy may eventually learn of your location through normal or unavoidable activities, and Intelligence reports, it does not mean that the value of the camouflage has been lost. The enemy pilot must still find the specific target with his eyes before he can successfully attack. Flying at 250 miles per hour at 10,000 feet the enemy must aim 5 miles before reaching the target and he must start dropping his bombs 3¼ miles away. Or a strafing fighter has to find a target, aim and fire in a few seconds.

1. Discipline. The fundamental prerequisite of all successful camouflage is camouflage discipline. Camouflage discipline is like sanitary discipline, gas discipline or any form of discipline. It consists of paying attention to details. A well-disciplined soldier would not be careless about displaying signs of activity in a position any more than he would be careless about his gas mask. Proper camouflage discipline is achieved by training the members to understand the necessity for (a) prevention of any change in appearance of terrain and (b) the maintenance and renewal of camouflage material.

2. Camouflage Principles. Remember that misused camouflage is worse than none at all. Here are some of the most important considerations to follow in hiding or disguising your presence from the enemy.

(a) Location or selection of position is of critical importance. Valley floors have sparse natural cover, yet dry washes (wadis) with a thicker growth of vegetation offer opportunities for natural concealment and defilade from oblique observation. In general, it will be necessary to hide "on the pattern" rather than under or behind it, because of the low cover.

(b) Avoid regular shadows. Each object casts a typical shadow by which it can often be identified on an aerial photograph. By means

of camouflage break up or distort this shadow. Try to make it blend into the terrain and make maximum use of natural shadows.

For camouflage materials use natural materials such as vegetation and debris wherever possible. Because of lack of vegetation in the desert natural materials will be rare. You will have to use artificial materials such as camouflage nets, paints, etc.

(c) Garnishing the nets. It is the garnishing of the net, not the net itself, which provides the concealment. The garnishing may be natural or artificial. Use natural materials where possible, but these are rare in the desert. The most satisfactory types of artificial garnishing for mobile warfare are strips of colored cloth, osnaburg, burlap, feathers, etc. For the desert, a net garnished with 60-80% sand color, 10-20% light green color, and 10-20% olive drab color is satisfactory for general use. Coverage should be 90% in center, thinning out to 10% at the edges. This permits light to pass through and prevents formation of fixed outline shadows. Tie the net in with some natural feature, such as brush or camel grass, to increase its effectiveness. Camouflage nets shrink when they get wet and expand as they dry out--adjust them with changes in weather conditions.

(d) Reduce visibility by texturing, toning down and coloration. Rough surfaces photograph darker than smooth surfaces. Use adhesive, or protective painting of oil and grease to which sand will adhere. All reflecting surfaces should be textured or painted to photograph the same shade as the surrounding natural features.

(e) Use decoys in the form of dummy aircraft, guns, airdromes and other installations to divert enemy planes from real fields in the vicinity. Dummy installations deceive the enemy as to your strength, and make him waste his blows. But remember that dummy installations must be carefully planned and must show the activity of a normal field and must themselves be camouflaged to a degree.

3. What to Camouflage

Which of these camouflage principles should be applied to the disguising or hiding of aircraft? Of trucks and vehicles? Of installations? The answer is: use all that are necessary to hide your presence from the enemy. Here is how you can effectively camouflage aircraft, vehicles, airdromes, and other installations.

(a) Aircraft

1. Keep dispersed and use nets and natural materials to break up outlines and conceal regular shadows. Great care should be taken to draw the net tight and away from the plane allowing it to touch the plane in as few places as possible. For planes on the alert, a light framework should be constructed to carry the nets with arrangement for the quick release of nets in front of the plane.

2. Employ protective painting to tone down and texture surfaces which do not blend in with the natural surroundings.

(b) Airdromes

1. Keep airdromes and runways dispersed.

2. Worn surfaces on a stabilized base should match the terrain in texture and color.

3. Facilities must be dispersed and in camouflaged shelter.

(c) Vehicles

1. Avoid converging tracks disclosing the location of important installations. It is impossible to conceal tracks except on rocky ground. Use existing roads wherever possible. To the enemy new roads and paths are certain signs of unusual activity. Do not end the road abruptly at a position; continue it to a decoy installation or another road.

2. Park vehicles head-on, never broadside to the sun. This will minimize the shadow. Best results can be obtained by having the shadow fall on low vegetation or rough ground.

3. Employ natural materials and camouflage nets to break up vehicle outlines. See that your net is properly garnished. Cover the vehicles with the net even if at halt for only a few minutes. Strive to get similarity to the desert floor by placing shrubs on and about the net. Break up the outline by placing props under the net so that it does not cling to the vehicle.

4. Paint or texture reflecting parts of the vehicle. Never wash vehicles to the extent that the paint wears off. Do not clean surfaces that will reflect light--texture them instead. Paint them with a film of oil or grease to which sand will adhere. Windshields should be similarly treated to prevent glass-flash but leave clear a 2" by 8" rectangle for viewing.

5. Maintain strict discipline with regard to lights at night, especially at maintenance and operation tents.

(d) Supply Dumps

1. Stack boxes or tins in an irregular outline and add natural and artificial materials to blend in with the area. Debris, sandbags, nets, etc. will serve for covering. When practical, dig pits for the dumps.

2. Stack boxes in the shape of a native hut or building or make them resemble an extension of such a structure.

3. Supply trucks should halt and disperse at least two miles from the depot. Nets or drapes should be used at halts.

(e) Decoys. The use of decoys is a job of display rather than of concealment. They should be realistic to be of value and their

environment must contain the activity and the associated features of real operations. Slit trenches, tracks, vehicles, and debris should be present. Also there should be an operating crew designated to maintain it and give it life.

C. Protection of Personnel

The ground is your best friend in time of trouble. Learn how to dig in quickly. Learn how to size up the local terrain, to appreciate the cover; even the flattest ground offers some concealment and protection. Observe the following which is based on practical experience:

1. Slit trenches are an absolute necessity for protection against bombing, artillery fire and strafing. They will afford safety and protection against everything but a direct hit and will minimize injury and loss of personnel. You cannot have too many slit trenches. Dig them in a dispersed and irregular pattern.

2. Slit trenches are easy to prepare. Outline the trench, then pile the dirt and sand irregularly around the edge of the pit.

3. When you move into an area that is at all liable to surprise air attack, dig slit trenches first, before camp is pitched. Dig them in all areas where personnel will live and work--adjacent to living quarters, messes, maintenance pits, installations, etc. Where areas are subject to constant attack, slit trenches should also be dug at intervals along roads and paths; make them accesible for quick use wherever personnel may be caught by surprise attack. Learn the location of all slit trenches. Use all available concealment.

4. If you are caught in a surprise attack and there is no slit trench available, dive for natural cover, if near. Otherwise lie flat on the ground. Familiarize yourself thoroughly with the local terrain--it may save your life some day.

5. In the desert bomb-proof shelters are difficult to erect. Dig in only the most important installations and equipment. Generally, operations and HQ tents should be made bombproof. Dig a hole and sandbag the sides.

6. All tents should be irregularly dispersed and dug in for protection against strafing and bombing.

7. Do not look up if you hear the roar of a plane overhead. Your face, being light, reflects light and attracts attention. Dab the face with mud or paint to tone it down.

8. When under cover do not move. Camouflage against movement is practically impossible. Where nature has failed, man is hardly likely to succeed. The zebra retains its camouflage property so long as it remains stationary. At the first movement, all illusion is lost.

9. Success in protection of personnel requires constant vigilance and well trained soldiers. If one truck or tent is seen it makes little difference that the rest of the installation is perfectly covered. Emphasize to all men the danger of vehicles parked in open along roads or near installations; the danger of needless telltale tracks around a position; and the danger of insufficient dispersion.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE DESERT (THREE LECTURES)

D-III LECTURE III—SURVIVAL

Prepared by

THE ARCTIC, DESERT AND TROPIC INFORMATION CENTER
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ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
ARMY AIR FORCES

* * *

School Lectures

The Desert

Lecture III
Survival

"To him who knows it, the desert can be a fortress; to him who does not, it can be a death trap."--A British Commander

I. MASTERING THE DESERT

The desert is a mortal enemy of the unprepared. Heat, sun glare, and limited supplies of water make life uncomfortable enough for units stationed in desert country, but for the man separated from his unit, or forced down, the problem is a matter of life or death. To survive in such a situation a man must be well-informed, fit, and resourceful. He cannot depend on others to tell him what to do. He must make his own decisions, and they must be correct, or he goes under.

Every theatre of operations from Africa to the South Pacific has a certain amount of desert terrain. You must know how to fight, operate, and survive on arid land. Victory in Africa has not relieved Allied flyers of the responsibility of preparing for desert emergency. The desert routes will still be flown, and new desert areas will become combat zones.

II. PREFLIGHT PRECAUTIONS

Before you fly over any desert region, make a study of the particular situation you will face. Anticipate problems and difficulties that are likely to arise. Perilous adventure is frequently a mark of incompetence, a failure to observe carefully the situation to which one must adjust himself, and failure to make adequate preparation. Arm yourself with water and food, especially water, the weapons necessary to fight the desert. It is too late to prepare once you are in the air.

Here are some handy tips to follow, tips which have saved many a man who has had to fight for his life in the desert. Discipline yourself by these rules.

A. Check Equipment

Check your emergency equipment carefully before every takeoff, and become thoroughly familiar with every item.

In certain theatres special essentials will be issued by your Intelligence Officer in the form of Escape Aids; but what you take aloft in your flight over the desert rests, in the last analysis, with you and your crew. Do some worrying about your own life. Add to the standard kits whatever special stuff you think you will need, and according to the carrying capacity of your ship. You will find, for example, that the nights are colder in some deserts, or parts of deserts, than in others. A drop of 30° at night is normal, and as much as 50° in parts of the Sahara in spring and fall, and in the Arabian and Syrian deserts. That means you will need warmer clothing! But whether your mission is over the deserts of Africa or those of Asia and Australia, you will need, above all:

1. Water. Take a tip from the camel--drink all you can before you start, and carry all you can with you. You should have along at least 5 gallons of water per man, in bombers. An adequate ration is a quart a day per man, so this will last at least 20 days. In fighter planes, stow as much water as you have room for. The small emergency cans are well suited for fighters.

2. Emergency Food Rations. The amount to take depends on the weight and space allowance of the aircraft. Food is secondary to water, and must be chosen with water requirements in mind. Take carbohydrate foods, such as candy and fruit, rather than meat and other protein foods which use up water in digestion.

3. Kits and Clothing. If your plane has space, here is what you will find useful:

a. Good sage-green colored goggles which cut out side glare.
b. Sweater, long trousers, long-sleeved shirt, stout-soled walking shoes.
c. Sun helmet or hat, or improvised head covering.
d. Compass, matches, and pocket knife.
e. Flashlight: 5-celled--or what you can get, or carry.
f. Signaling equipment: smoke bombs, metal mirror, Very pistol and cartridges.
g. First aid kit including halazone or iodine for purifying water, sterile dressings, and sulfa drugs.
h. A map showing the ground travel routes and wells in the operations area.

Much of this material is contained in the parachute pack.

4. Escape Aids. Special information and equipment may be supplied by the Intelligence Officer to prepare the flyer for specific conditions in the local theatre. These may include maps, messages to local inhabitants, local currency.

B. Local Populations

Another important preflight precaution is to find out all you can about the peoples of the region over which you will fly. You will have to depend on them for food and guidance. Are they friendly, indifferent, or hostile?

Learn all you can about their customs and manners, their language, their likes and dislikes, how best to develop their good will and cooperation.

This learning should start immediately. A soldier fights with his head, and stays alive by using it at the right time. The right time to start is now.

III. FORCED LANDINGS

If you are compelled to bring your ship down in the desert because of enemy action, mechanical trouble, sandstorm, or because you are lost or running short of fuel, do not get panicky. Excitement uses up energy and hinders good judgment. The desert offers plenty of suitable landing places, and your chances of resuming flight are good. In deciding on a landing, keep in mind the following:

A. If you are definitely lost, as in a sandstorm, do not waste gas in aimless flight. A precautionary landing with gear down has a good chance of success, and makes possible later takeoff and resumption of flight after the weather clears or after you are found by relief planes. A dead stick landing leaves little choice of terrain, and is hazardous under even the best conditions.

B. You can determine ground wind conditions by observing dust clouds or sand dune formations as you fly over them. Dunes, like ocean waves and snow drifts, usually run roughly at right angles to the direction of the prevailing wind. If there is a choice of landing parallel to the dunes or into the wind, land crosswind, parallel to the dunes, and land uphill, not down or across the slope. Avoid salt pans and wadis; your wheels may break through the crust.

C. Winds seldom if ever reach hurricane velocities in the desert. Velocities of 50 miles an hour are rare, but winds of 35 miles an hour are common enough. Rainstorms are infrequent, but may be of cloudburst intensity. If you make camp in a wadi or gully, be prepared to escape from rushing water in case of a sudden rain.

D. Landings during a sandstorm are no more difficult than during a heavy rain. Such landings should be made into the face of a wind with velocity of 35 miles per hour or greater. Thus your actual landing speed will be low, and the roll after landing will be short. Once on the ground, attend to several details immediately:

1. Plug up and cover all engine openings. If the plane is flyable, or can be repaired, the mechanical parts of the ship must be protected against the blowing sand. Sand can be your worst enemy; fight it at the outset.

2. Take personal cover and wait until the weather clears. Stay close to the ship.

E. If you are forced down by enemy action or mechanical or structural failure, make the best landing possible. It may or may not be advisable to land with gear retracted. But try to stick with the plane and bring it down. If as a last resort you have to bail out, watch the descent of the plane and try to reach the wreckage. The plane is better spotted from the air than you are; and even a wrecked plane can supply useful signaling and emergency equipment.

If you are forced down in enemy territory, burn all papers, smash and bury secret instruments, and burn the plane before striking out on foot.

IV. STICKING WITH THE PLANE--WHAT TO DO

If you are forced down in friendly territory, always stay with the plane and wait for rescue unless you are sure of your position and know that you can get back to your base on foot; or unless you know positively where to get water and assistance, and feel you can make it easily; or if you are sure you will not be found where you are. Bear in mind, however, that while you may be ten minutes' flying time from your base, this may mean a couple of days' walk on the ground.

If you stay with the ship you have a good chance of being picked up by a rescue plane. Your ship will be clearly seen from the air; but if you leave it, your own chances of being seen from the air are slim. You are just a tiny spot on the vast desert. Also, the plane may offer precious shade.

Here is what you can do personally to combat the desert, to help bring about your own rescue, to survive as long as you can:

A. Water

1. Ration your water and provisions carefully. If you have only a little water, do not eat. Do not worry about starving. With the minimum of activity required in remaining with a grounded plane, you will need little food; with water, you can exist with little or no food for weeks.

2. Do not gulp water. Follow the practice of desert nomads: just moisten your lips and rinse your mouth with water before swallowing. Think of your water supply as your invaluable bank account, standing between you and death. Conserve your liquid assets; put yourself on a strict budget.

3. Do not wash. You may use sand, as do the Arabs and Berbers, to cleanse yourself.

4. Do not smoke. This applies especially during the day. Smoking increases thirst.

B. Shelter and Personal Comfort

During your stay with a grounded plane get as comfortable as possible. (a) Stay out of the sun. Parking in the shadow of the fuselage is the simplest way. (b) Rig up an awning, or make a tent out of the parachute. (c) Do not stay inside the plane; the heat is likely to be too great. (d) Do not work while the sun is up; wait until the cool of dawn or evening. (e) Wear light clothing during the day, and warm clothing at night. (f) Keep shoes free of sand, and take them off during the day while resting under the shelter. (g) Improvise wrap-leggings from strips of fabric torn from your parachute, and wear on upper ankles to keep the sand out of your shoes. (h) Make sure your head is covered. (i) Make sure you cover any part of your skin exposed to the sun.

C. Signaling and Firebuilding

Set up a system of signals immediately. Some of the more practical methods are:

1. Radio. The radio is the most important rescue device. If you can get it working, the major part of the fight for survival is won. Erect a vertical aerial, which is more efficient than the horizontal aircraft aerial. Compose an S.O.S. message, giving your position if you know it. Transmit on prearranged frequency, and listen for a reply. If no reply is received, switch off and call again at fixed intervals. Conserve your batteries. Listen out before transmitting; insure that frequency is reasonably constant and that target station is not transmitting. Be certain that circuits other than the radio, such as lights and gunsights, are switched off. If possible, run the engine charging the generator during both transmission and reception. This will bring better signals and lengthen battery life. Sufficient RPM's are necessary to bring cut-out in so that the generator takes over the load. Intersperse with 15-second dashes to allow D/F station to take your bearing.

2. Fire. The best type of signal on the desert. Employ bright flames at night, and smoke in the daytime. Look for scrubby desert bushes to use as fuel; camel dung also makes a fair fuel. If there is no natural fuel, use plane cushions, floor mats, etc., and wicks of parachute cloth, and douse with engine oil or gasoline. Ignite and from time to time smother it with a little sand--this will make a cloud of smoke visible at a distance. Use a smoke or fire signal only in friendly territory.

3. Reflecting mirror. Your signaling mirror, if you have it, or your rear-view mirror, or even a polished food tin will send a flash from the sun that can be seen for miles. Learn how to use the mirror by practicing in advance.

4. Reflections from plane. Scrape the paint from the surface of the wings and polish with sand or gravel. In daylight the flash can be seen from the air. Polish the inside of the cowling and lay upside down on the wings.

5. Very pistol. Fire at periodic intervals. Do not use all

cartridges at one time. Save some for emergencies. Fire them only when you see or hear an approaching plane.

6. Rocket flares and smoke bombs. Keep these in readiness and set them off on seeing or hearing plane approaching.

V. THE TREK ACROSS COUNTRY

There are some exceptions to the rule that one should remain with the plane after a forced landing. (1) When you feel, after a careful appraisal of the situation, that there is no hope of rescue; (2) When you are positive of your position and know that you can get back to your base on foot, or know where to go for water and assistance; (3) If you come down in enemy territory, you must destroy your plane, papers, and instruments, and leave.

A. On Abandoning the Plane

If you have decided that your best bet to survive is to travel out in hopes of finding an oasis or settlement, prepare carefully.

1. Study your maps, determine your position, and have some idea where you should attempt to go. Do not start out without a specific destination.

2. Consider your water supply, your equipment, your physical condition, and the possibility of holding out until you reach safety.

3. Salvage from the plane anything that might help you travel on foot or add to your personal comfort. Take a compass, maps, and a 10-foot square of silk from your parachute.

4. Take along your entire water supply--sacrifice everything else for it.

5. If in friendly territory, leave a sign on your plane urging troops and others who may come along to refrain from souvenir-hunting. Say something like: "Don't touch, damage, or remove parts from this plane. It will be salvaged soon and will fly and fight again. It may some day help to save your life. Leave it alone."

Leave another note in the ship outlining your proposed route and the date and circumstances of your departure. It may help speed rescue by searchers. Leave directional marks on the ground, such as a large arrow dug into the sand, or made of rocks or brush, to indicate to air searchers the route you are taking.

B. Desert Travel--Water and Wits against the Desert

Interpret the following practical suggestions in a flexible fashion, to fit the particular problems and circumstances that may arise. Each man has his own peculiarities and physical requirements: some need more water than others, some can stand more heat. Know yourself, and make allowances.

1. Follow a definite plan of travel. Distances in the desert are deceptive. Once you have established your position, consult your maps and figure out the way toward some known route of travel, some source of water, or an inhabited area. Trust your compass rather than your own conviction. You can check your compass by the sun. At midday the shadow of a vertical stake or improvised plumb line is shortest and points either true north or true south, depending on the latitude and time of year. To determine north or south, watch which way the shadow moves. It always moves east.

If the shadow of the top of a stake is marked on the ground some time before noon and again at the same time interval after midday, for example 1030 and 1330, a line connecting the afternoon and morning points will run due east and west. The afternoon mark will be at the east end of the line.

At night, there is another indication besides the Dipper and the Cross. East and west can be determined from the point in the horizon where the stars rise and set vertically and are moving most rapidly.

2. Follow the easiest route possible. Avoid soft sand and terrain. It is easier to take the longer route around obstacles. Traverse ridges where practicable, to be more easily seen from the air. Keep a steady pace, and take a rest, or "break", for ten minutes every hour.

3. Travel light. Take along only the bare necessities.

a. Water, it must be repeated, is the key to survival. Five U. S. gallons will weight about 40 pounds, without containers. A foot traveler should carry not much more than 20 pounds on his back. If you travel only at night, you can get on well with a quart a day. With a minimum of activity, a pint a day will keep a man going for a number of days.

b. Food. Reduce it to a minimum, especially if you are short on water. Carry carbohydrate foods which are easily digestible. Protein foods, such as meats and milk products, leave digestion wastes which require water for elimination in urine; therefore proteins should be avoided when water is short.

c. Carry a compass, knife and small whetstone, maps, sun glasses, salt tablets, matches, halazone tablets. Because wild life is hard to get, a gun is not so important as in other areas. Have a hat, long sleeves and pants.

d. Do not take salt tablets if you have less than a quart of water per day. Cut out cigarettes during the day and eat food only at night and during the early hours of the morning.

4. Night travel. You will last longer if you travel only at night. Take it easy in the day time during the summer. Stay in the shade of your plane or your parachute. Certainly, if your water is low, and if you can maintain direction, night travel is mandatory. At night

a flashlight may be used in friendly territory. For direction, use your compass and the stars. The North, or Pole Star, is the best indicator of direction in the northern hemisphere. If you cannot identify the Big Dipper, then learn how tonight. Follow the outline of the stars in the constellation, away from the handle; the two stars on the far edge, from the bottom to the rim, point toward the Pole Star, which is at an apparent distance from the Dipper equal to about five times the distance between the two pointer stars. The Pole Star is also the end of the handle of the Little Dipper.

In the southern hemisphere, the problem is complicated by the absence of any bright star over the south pole. The long axis of the Southern Cross points in the direction of the south pole. The south pole can be assumed to be in a dark area of the sky, about midway between the Cross and Archernar, a first-magnitude star that is the end of the constellation Eridanus, the river.

5. Digging in during the day. If your program calls for night travel, rest during the day. If you are traveling in enemy territory, you will have to dig in and camouflage your position. Another reason to dig in is to escape from the sun. Cover your trench with a piece of parachute, or with desert grass. Leave air space beneath the cover.

6. Guard against the sun. Keep your head covered when in the sun. Wear your glasses for protection against glare and blown sand. Follow the custom of the Tuareg people of the Sahara: veil the face to protect against blowing sand. If you are without glasses or should break them, improvise goggles out of wood or canvas. Make eye-slits only large enough for you to peer through. You will then be protected from the more dangerous rays of the sun.

7. Seek native help whenever and wherever you can. If you are lost in a desert area the natives offer you your best chance of reaching an oasis and surviving. Be on watch for caravan routes, the railroads of the desert. When meeting natives, be pleasant and courteous. Do not display firearms, and do not act as if you demand assistance.

In the Sahara, the Tuareg, Berber, and Arab tribes will be friendly. In March, 1943, three American fliers were forced down in the southern Sahara and after traveling for four days over sand dunes and desert wasteland, spotted a caravan in the distance. They were picked up, given food and water, told by signs that a settlement was four days away, and then were hoisted on camels as the caravan moved off in that direction. Two of the natives rode on through the night and the following day and night to bring help from French soldiers at the post. These natives had had no rest in two and one-half days.

In the barren wastelands of Australia, the natives have an uncanny ability to follow tracks. A crewman who bailed out of a B-24 in a blinding storm and wandered in the wild bush country for 111 days was tracked down by an Australian blackfellow within 48 hours. The natives are friendly to white men, and take a low view of the Japanese.

8. Finding food in an emergency. Game animals and food plants are neither abundant nor uniformly distributed in the desert. In the immediate vicinity of a water hole, or where there is a light growth of brush, rabbits, other rodents, and small birds may be found. Rabbits and large lizards are common in the deserts of Australia. Also, roots of the eucalyptus (gum tree or mallee) in Australia provide water and food.

The gazelle is common to the African, Middle Eastern, and Gobi deserts. They travel in herds, and can run short distances at a speed of 50 miles per hour. They can be approached only on the lee side of the wind, keeping out of sight. Only a good shot with a high-powered rifle will bring one down. They are fond of tobacco but will not approach tobacco that has come in contact with the human body.

In rocky sections of the Sahara--and much of the Sahara is rocky--edible snails about an inch long are found in rock crevices. Empty shells are sometimes filled with honey deposited by the honey-bee. Such shells can be spotted because of the wax covering which seals the opening. In southern Algeria, the Arabs and the Berbers search for these honey-filled shells. They are not common but you may find 20 or 30 of them in the course of a morning. Live snails are best prepared by roasting over a fire. Make an opening in one side of the shell and thrust a prong through to emerge at the natural opening, to keep the snail from escaping.

Palms are found at streams and water holes, and are a good source of food. The trees are the precious property of the natives, and must not be injured. Where there are water and trees, you are likely to find natives; look for people before eating. In an emergency, eat the fruit of the tree (dates, or coconuts) or even the palm cabbage, a tender shoot which extends up from the point where the leaves spread out. It can be eaten raw or cooked.

Near swamps in Middle Eastern deserts, wild pig is common. The female when with her young, or when wounded, will attack. Avoid her. If you are a good shot with a rifle, aim between the eyes, or downward toward the heart at the back of the neck.

The dingo or wild dog is widely distributed in Australia and may be considered a source of food, if you can bring one down. Often its presence is an indication you are approaching a native settlement.

In any desert, if there is green vegetation there is bird and animal life, but you may have to look for it at night or dig it out of the ground. Rodents can be attracted with a torch at night.

9. Finding water.

a. Some deserts become very humid at night. Utilize this humidity by collecting dew. Scoop a shallow basin in the ground, about three feet in diameter. Cover the basin with a piece of your parachute. Over this build a pyramid of stones at least three feet high. During the night dew will collect in the chinks between the stones, and trickle

down through the inside of the pyramid onto the chute. The chute will sag with water. Place a vessel of some kind beneath the cloth so that the water will not drip into the ground and be lost.

b. Where there are leafy bushes, you can collect dew off the leaves during the early morning hours. One flyer kept himself alive for days in this manner.

c. If you find damp sand, especially at a low point, dig a hole and wait. Water may percolate into the well. If you do not find damp sand, pick the lowest point between sand dunes and dig 3 to 6 feet. If the sand becomes damp, continue to dig until you find wet sand. The top of the hole will have to have a gentle slope. When wet sand is reached, keep the hole covered to prevent evaporation, and wait for the water to come in. In the stony desert, pick a wadi. Dig down in the gravel at the point of maximum curvature of the outside bend of the dry wadi channel. On the desert surface away from a wadi, pick the lowest point which may be the center of a mud flat. During much of the year, wet mud can be secured which, if collected and wrung out in a piece of parachute, will give a few drops of water.

d. Follow the tracks of animals and the flight of birds. They may be going toward water. Look for green vegetation. It means that water is underneath or close by.

e. Search for water holes and wells along caravan routes which are shown on your map. Determine from the intelligence officer or some others familiar with your region the types of water sources in the district, and mark them on your map. Some are open cisterns which hold considerable water in the winter after a rain but are dry in the summer. Some are mud flats, the larger of which will hold water for a month or so after a heavy rain in the winter. Others are wells; others are permanent springs (oases), but most are water holes in wadi beds or in low places, which the Arabs cover and hide after using.

f. Remember that all water from wells must be boiled or sterilized. It may be polluted with urine from sheep, goats, camels, and other animals brought there by the nomad. It may contain germs of typhoid, dysentery, or other diseases. Purify the water either by boiling for about 5 minutes, or by dissolving one halazone tablet in each quart. More than one tablet may be necessary. Let the water stand 30 minutes. If there is no slight odor of chlorine, the water is not safe; add another tablet. Iodine can also be used, two drops for each quart of water. When water is murky, three or four drops of iodine per quart may be necessary.

g. Water from desert plants. Some desert plants store water in their trunks, branches, or roots the way camels store water in their stomachs. Cactus grows on some deserts. In Australia, besides the eucalyptus already mentioned, there is the oleosa, an evergreen bush about 15 feet high. The roots lie from two to nine inches below the ground and may be 50 feet in length. Cut the root into pieces about a foot long, hold a piece vertically, and let the water drip into a container. You can make a water bottle out of a root by plugging up the cut end.

Palms yield water from trunks and branches, but it is apparent from the nature of their growth that one need not try to extract water from the plant. For palms grow only where there is plenty of ground water. Look for a spring, or dig. By all means try to avoid harming the trees themselves, since they are precious to the natives.

VI. GUARDING YOUR HEALTH: HEAT, SUN, AND SICKNESS.

There is nothing in the rays of the sun which is mysteriously dangerous to human beings, or affects their brains. People collapse in the sun because their bodies absorb more heat than they can throw off, and not because sun penetrates through the skull to the brain. There are three kinds of heat collapse, and each requires special treatment.

A. Heat Cramps. These occur in the muscles of the legs or abdomen and are usually a warning of approaching heat exhaustion, resulting from insufficient salt in the body. Treatment: Massage the sore muscles gently; apply moderate heat; take salt in water; get plenty of rest.

B. Heat Exhaustion. This may occur from direct exposure to the sun, from staying in the hot interior of the plane too long, or from lack of salt brought on by excessive perspiration. The face turns red, then pale; there is a great deal of sweating; the skin is moist and cool. Body temperature sinks below normal (98.6). The victim feels faint but does not become unconscious. If he does pass out, it is only for a few seconds or minutes. Treatment: Place the patient flat on his back and lower his head. Since he is cool, apply warmth. Give the patient salt--about one teaspoonful in enough water to dissolve it. This should be repeated three times a day.

C. Heat Stroke. The face becomes beet-red; there is severe headache; the skin becomes hot and dry; all sweating stops. The pulse is fast, full, and strong; body temperature soars above normal. The victim becomes unconscious or semi-conscious. Treatment: Shelter the patient from the sun. Lay him down flat. Apply cool sponges made of clothes or rags to the body. Get the body temperature down. Do not give whiskey, tea, or coffee.

SALTS AND WATER--USE ONE, SAVE THE OTHER, AND YOU'LL GET ALONG IN THE DESERT.

SUMMARY ON DESERT SURVIVAL

1. Start learning and preparing immediately.

2. Know what emergency equipment is available; check it before every mission.

3. Carry as much water as possible per man. Five gallons weigh 40 lb. You can manage well on 2 quarts a day for all purposes, and on 1 quart a day if you travel only at night.

4. Food is secondary to water. Do not take food which induces thirst.

5. Other valuable equipment: compass; salt and halazone tablets; sunglasses; signaling equipment--flares, metal mirror; first aid kit; high shoes; pocket knife.

6. Learn as much as you can about the natives: their location, religious beliefs, social customs, language.

7. Take along messages in Arabic, requesting natives' cooperation.

8. Memorize the principal features of the map of the area over which you are to fly. You may have to walk out without a map.

9. Do not bail out; try to land the plane; avoid dead-stick landing.

10. If plane if flyable, plug up openings, and try to keep it clean.

11. Stay with the plane and await rescue. Have signals ready.

12. Ration water and food for a long stay. Sip water; do not gulp it. Do not wash; do not smoke if water is low.

13. Stay out of plane by day; stay out of sun, and keep head covered. Keep shoes free of sand; wear heavy clothes at night.

14. If convinced of necessity to abandon ship, have a destination and a route laid out.

15. Know how to tell direction, day or night, with or without compass.

16. Take all the water you can carry.

17. Leave a note in the plane, with date of departure, and direction.

18. Do not take salt tablets if your water supply is low.

19. Travel at night, unless well-equipped and sure of destination.

20. Water from wells must be boiled, or purified with halazone. Water may be found as dew on plants, or in stems or roots.

21. Avoid sunburn, heat cramps, heat exhaustion, heat stroke.

22. Use your wits, and save water.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

THE TROPICS (THREE LECTURES)

T-I. LECTURE I—GENERAL CONDITIONS

Prepared by

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ARMY AIR FORCES
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School Lectures

THE TROPICS

Lecture I:
General Conditions

I. ADAPTATION

We have all read inspiring stories of the brave airman who, haggard and sick, staggers into a mission compound or native village, having survived a month of hell in the jungle after a force-down or bail-out. Such adventures have been tributes to the courage and stamina of our men, and their will to come back and fight again. But it must be admitted that some of the suffering could have been avoided. Many of these men have declared that if they knew at the time of their ordeal what they later learned about tropical food, diseases, and travel, they would have had little trouble. When Air Force men take advantage of the knowledge which is available, the time may come when flyers who bail-out unwounded, but then turn up bitten, starved, and sick, may lose prestige, rather than gain it, among their fellows.

A. Adjustment for Efficiency.

The time of adventure and heroics is coming to a close. Whatever happens in Europe, whatever happens in Alaska and China, it is clear that our forces, and especially our Air Forces, face a long struggle in the Pacific and Malaysia, on tropical islands and over great tropical areas of forest and plain. We must get used to the idea of an extended period of operations, in which everyday efficiency alone can carry us through. We should actively avoid risks and adventure, in order to achieve results. We must make proper adjustments to life in non-temperate climates. We must adjust our mind and body to the conditions of wet and dry seasons, to strange fruits and plants and to populations who are better adapted than we to their environment.

Tropical lands are rich, and support all kinds of life abundantly, both plant and animal, large living things and small. But we need special knowledge in order to survive. Knowledge will make us aware of the different kinds of jungle land, of the different kinds of native populations, of various natural resources, of the things to avoid and the things to seek in the rich environment. Your efficiency and maybe your life will depend on knowing how to live and carry out everyday operations under unusual conditions.

B. Misconceptions to Debunk

A first step in learning how to live in the tropics is to unlearn wrong impressions. We must correct ideas retained from tall tales about man-eating snakes, poisonous trees which reach down and capture their victims, head-hunting or cannibalistic natives who exterminate all outsiders. We laugh at foreigners who fear a trip to Chicago because of stories of "pineapples" and tommy-gun typists and trigger-men. The informed person on tropical regions would laugh at fears of the "jungle." Both kinds of legends come from sensational fiction, moving pictures, and so-called "explorers" who exaggerate their accomplishments by magnifying the dangers they encountered. There are, certainly, poisonous animals, fish, and plants, but they are not many, and one can learn to avoid them. Cannibals still exist in the rugged hills of interior New Guinea. But most natives have been found to be naive, curious, and almost always friendly to Allied soldiers. Some explorers claim that the jungle is safer than a big city. More people per 1000 are killed in normal New York traffic than by the snakes and wild animals of the tropics. We must learn the rules of living in the jungle, just as we learn traffic rules. When we have knowledge, we need not fear.

C. Need for Knowledge

How do natives live in their tropical environments? Certain phases of physical adaptation we cannot hope to achieve entirely. We cannot acquire a black skin pigmentation to protect us from sunburn, but we can gradually acquire a heavy tan that will do much to prevent a burn. Adjustments of temperature regulation, metabolic rate, and resistance to some diseases, which have been developed by natives over centuries as a safeguard against extreme conditions of heat and moisture, cannot be acquired in a short time. But we can learn and put to use the results of scientific study. We can learn what foods to eat, how best to prepare them, how to safeguard food and water against infective organisms. Our scientists have been gathering information for years to help us face just such problems as those before us. Individual soldiers do not have to make their own experimentation, testing theories with their lives. The facts are proved and waiting to be learned. Furthermore, equipment and emergency kits have been carefully worked out, and all we need is common sense to take advantage of this equipment, to keep it ready for use at all times and to follow instructions for use. Again, there will soon be small excuse for hardship after a safe force-down.

What are some of the general conditions we shall have to face from day to day in the tropics, conditions of climate, vegetation, animal life, and social custom, the understanding of which will make life easier, or indeed possible, whether at the air base, or in the vastness of a tropical forest?

II. CLIMATE AND LIVING CONDITIONS

First, climate. Most of the area in which there will be fighting--until we get near Japan itself--is tropical. Northern Australia, New Guinea, Borneo, Java, Sumatra, Malaya, Thailand, Indo-China, Burma, and the multitude of small islands not yet put on the active war-map, as the Solomons have been -- all these are located between the Tropic of Cancer and the Tropic of Capricorn, $23\frac{1}{2}^{\circ}$ north and $23\frac{1}{2}^{\circ}$ south of the Equator. This is the great tropical belt of the earth. There is not as great differentiation between winter and summer as in the temperate zones; the significant seasonal rhythm is not from hot to cold, but from wet to dry. The dry months because of lower humidity are likely to be more comfortable than the wet months. The extent of contrast between wet and dry, and the months which are wet or dry, differ from region to region and vary north and south of the Equator. Days and nights remain about the same length throughout the year. Dawn and darkness come quickly, without the long periods of twilight normal in north and south temperate zones. A factor to consider is the monotony of tropical climate — one day will be like the next in temperature and moisture.

A. General Characteristics

The thick tropical rain forests in most of the lowlands of the Indies, Burma, Malaya, or Sumatra are the result of rich soil and heavy rainfall. We must immediately stop to remind ourselves that the word "jungle" itself is a broad, loose term. The vegetation of tropical areas may consist of dense tropical rain forests, heavy bush, thick tall grass, mangrove swamp, open prairie-like land or intensively cultivated areas.

1. Weather

On the mainland of southeast Asia the wet and dry seasons are dominated by the monsoons, or seasonal winds. The northwest monsoon winds blow from the north out of the great land mass of Asia, from November to March. These winds are cooler and dryer than the air over the southern ocean. From May to September southerly winds blow up from the ocean, bearing much rain. The islands of the Pacific are dominated not primarily by the monsoon, but by the trade winds, and differ from the mainland and from each other in prevailing temperatures and exact periods of wet and dry. Even on the same island factors which affect seasons are: distance from source of the monsoon; mountain ranges which intercept moisture; closeness to the sea; altitude of the area, or height of mountains;

The atmosphere of the tropics is usually humid and uncomfortable for white people recently arrived from temperate climates. Certain factors do promote comfort, such as: protection from the sun; evaporation of moisture from skin surfaces; air movement aiding evaporation; bathing; etc.

The year-round average of almost 80° in a large portion of the Netherland Indies, coupled with a continual humidity of 85 to 90, contrasts with New York City's mean annual temperature of 53. The difficulty of getting used to the climate is obvious.

2. Variety in Geography and Vegetation

The islands range from Java, the most intensely cultivated and densely populated area in the Indies, and Sumatra, which is the largest, to tiny coral reefs, barren and uncharted. Maps of a large part of the island area are incomplete or inaccurate, although this information is rapidly being filled in. It is necessary for our forces to map many regions by aerial photography. Parts of Borneo and New Guinea and Sumatra are unexplored, especially in the interior mountainous sections. In the uncultivated lowlands, vegetation is lush, quick-growing, and often fed by over-flowing rivers. On the highlands or plateaus the forests are of a different kind. Even though these regions in the mountains are clear of rain forests, travel over them may be difficult because of thick tall grass, bushes, and volcanic rock surfaces. Steep hills add to the difficulty.

B. Adjustment to Conditions

Different physical conditions will demand changes in living habits. Clothing should be light, loose, and porous, to allow cooling of the body by evaporation and by circulation of air. It must be adequate for protecting the skin from injury and from sun. Finally, it must also protect us against mosquitoes, flies, ticks and leeches. The nation's science is providing the best clothing for this variety of demands.

There are some interesting scientific findings on the effects of tropical climate on men. The physiology of white persons from temperate climates shows the following changes: 1. a lowering of the respiration rate; 2. a slight rise in normal body temperature; 3. a possible increase in lung capacity; 4. increased sweating to help cool body; 5. lowering of the amount of urine passed; 6. lessened appetite, especially for proteins and fats; 7. slight rise in blood pressure; 8. increase in pulse rate for a time, followed after a stay of some length by a decrease in pulse rate; 9. reduced blood volume, and increased concentration of blood.

There are certain conscious changes which may be observed: increased feeling of tiredness; need for more sleep, or lack of ability to sleep; marked change in appetite; increased thirst; varying degrees of heat discomfort; "night-blindness" from over-exposure to bright sun.

C. Food Habits

Our food habits will have to be changed. No matter how strenuous the efforts of the Quartermaster, there will inevitably be shortages of some foods to which we have become accustomed. Mess personnel will need to learn about the possibilities of using local

plant and animal foods, although even a small army post is likely to exhaust native supplies and food plants. Thus these can never be more than a supplement to regular army rations. American soldiers will need to learn to like many strange but really tasteful native foods. Native diets may be deficient in some vitamins, which can be supplied by combination with proper army rations. Deficiency in the vitamin-B group, and protein, has been noted. Efforts should be made to supply red meats, liver or liver paste, bean sprouts, or condiments used locally which are known to contain the B complex.

1. Care against Contamination

While recognizing the need to vary and enrich our diet from native sources, we must be constantly on our guard. Fruits and vegetables are likely to be contaminated. Great care should be exercised to see that fruits and vegetables are harvested, transported, and stored under sanitary conditions. Peeled, fruits with undamaged skins are fairly safe; even so, the army can take no chances. Many of the native plants may have been cultivated with "night soil," or human waste. The Chinese and other peoples of the Orient sprinkle this on leafy vegetables and by this means may contaminate them with human disease germs. Most natives have little understanding of the likelihood that their produce will be exposed to every kind of digestive disease existing in the village.

The same kind of care must be applied to fresh-water fish and shell-fish, and those salt water species which feed in shallows close to shore. Fresh water is a dangerous carrier of parasite organisms. Salt-water fish are safe from disease germs, but a few may be poisonous or venomous. A point to be stressed: fish spoil quickly. They must be cooked and consumed immediately, or they become dangerous. Some kinds of fish, although not poisonous, have the reputation of being so because they become tainted quickly.

2. Water

When in the tropics soldiers will feel like drinking much greater quantities of water. The increase in water intake is not only desirable, but necessary. When good water is available drink it. Under some conditions soldiers will have to learn to do with reduced rations of water. An old Marine gunnery sergeant on Guadalcanal said: "This 1942 model recruit we are getting can drink more water than six old-timers. We have to stress water discipline all the time." It is more true than ever that water must be considered contaminated and unfit for drinking until approved by a medical officer or purified, preferably by boiling. Halazone tablets are now considered a standard article in the jungle soldier's kit, to serve as an emergency measure when there is not sufficient time or facility for thorough boiling of water. In emergencies water from mountain streams in uninhabited regions may be used. Water can be had from coconuts and fruits. Some types of vines when cut yield water for drinking.

D. Hazards to Health

There are other hazards to living in tropical regions. Number 1 and most important is the mosquito. The tropical mosquito does not always make so much noise, or drill so deep, as the kind back home, but he may carry malaria, this war's greatest cause of casualties, or filariasis. These diseases have serious consequences; they are disabling and may cause death or permanent injury. Dengue, or "breakbone fever", is more temporary in effect. Since the mosquito is so wide-spread, it is hard to avoid; but trained, intelligent troops can greatly reduce the risk of disease.

The Number 2 hazard is found in other insects--flies, which carry most gastro-intestinal disease, and ticks and mites, which are responsible for other diseases and which cause much annoyance. Number 3 hazard is careless travel; thorns, nettle pricks, grassblade cuts, rock bruises, in fact anything that breaks the skin, can be the beginning of infection. The Number 4 hazard may be leeches, flukeworms, and other parasites. So it is clear that the soldier in the tropics must be eternally on guard. The health problem is treated more fully in lecture II of this series.

E. Need for Discipline and Training

Experiences of the past show that many white men in the tropics go to seed, lose their nerve, give up trying to fight illness, bad food, and alcohol. They "rot". But all this need not, and is not likely to happen to any American soldier. Many white men have lived long and useful lives in the tropics, having made proper adjustments. They were busy, active men. Soldiers will be busy and active. Unusual irritability, lack of exercise, moral let-down--these will be prevented in great part by contact with the enemy and vigorous first sergeants. One can live healthily and energetically in the tropics, but the key-work is discipline, discipline with knowledge which should be the basis of discipline. The discipline must fit the tropics.

And behind this discipline is training. The men may have heard again and again the reasons for not drinking out of clear bubbling streams, but they will need to act on the knowledge. Quinine or atabrine must be taken according to instructions. Proper safeguards against mosquitoes must be arranged. Proper arrangements for the elimination of waste must be part of the daily routine behavior of each soldier. You cannot leave such things to the sanitary corps when you are in fox holes in Sumatra, in Malaya, or in Burma. The situation reported by a master gunnery sergeant in Guadalcanal must not be repeated: "Some lousy undisciplined recruits defecated in fox-holes, which caused trouble in the dark." "Trouble" is a mild bit of language from a sergeant, but each of us can imagine the situation.

The training program for soldiers must be started long before the men reach tropical climate. The consensus of opinion of commanders on Guadalcanal, both Marine and Infantry, is that three months of bivouacking, scouting, jungle marching, maneuvering, are necessary before troops can be considered ready for active tropic duty. One reason why the Japs could put up so tenacious a resistance on

Guadalcanal and New Guinea is that they had gone through long preliminary training; our men lacked time and opportunity for this experience. But now our men are getting this training, and they are more than a match for the enemy.

III. THE NATIVES IN GENERAL

Many of us still believe that native peoples of tropical regions are wild, suspicious, and hostile to white people. This is largely false. First, white people are no new experience to most natives. Missionaries, traders, scientists, and more recently Army and Navy personnel have given natives a fairly clear idea of the white man and his ways. Second, a rapidly increasing number of reports from our own Air Force personnel make it clear that natives, far from being hostile, can be considered the most important single factor in the safety of forced-down or marooned military personnel. When you find the natives, or when they find you, your big worries are usually over. In preparation for either daily operations in the tropics, or emergency survival procedures, the greatest emphasis must be placed on learning the ways of the natives, how to approach, how to please, how to communicate, how to pay, how to show respect for them.

A. Their Right to Respect

We must be prepared, then, to treat the local inhabitants not as "natives", but as people. We must try to know what they think, what they want, how they are likely to react to us. If in the past they have had reasons to mistrust the white man, we must in our daily relations with them strive to overcome their prejudices and build up a bank account of good will. We know that the Japs have antagonized the natives in many areas by arrogance and exploitation. We must take advantage of this fact by establishing a clear contrast between Allied and Axis procedures. Some of us, to accomplish this, may have to readjust our ideas about other races.

We cannot of course ever know completely "how" the natives think, just as our mental processes must seem strange to them. (Always remember, if you think the natives are queer, that you seem much more so to them.) But we can assume that there can be a general kind of meeting of minds. They want respect, they want to be treated fairly; indeed, they want to be treated like human beings. They have a highly developed sense of dignity and hospitality, and, an important factor, they usually have a sense of humor, crude though it may seem to us. If we are not tense, fearful, or arrogant in our dealings with them, they are likely to respond with help and guidance. Above all, we must keep our word, once a promise or agreement is made.

Remember this: through generations of time, the native populations have become well adapted to their surroundings, and consider their way of life to be the only good one. They are not "savages." In fact, they can put up a good claim that they have made a better adjustment to life than the "civilized" races have. There is less mental disease among them, because they are not subjected to the many strains and pressures of "civilization". There is no fear of insecurity; when they do have wars (and war is not universal among the island populations), only minor devastation and death result.

B. Differences among Native Groups

The above remarks run the danger of being easy generalizations. Over so broad an area as the Pacific Islands and Southeast Asia, there are peoples as varied in appearance and manner of life as exist in the temperate zones. On the basis of physical appearance, manner of life, and language, scientists usually class the peoples of that part of the world as Polynesians, Melanesians, Micronesians, and Malaysians. Within each principal group many subdivisions may be recognized, and it is often difficult to place individuals accurately in their racial group.

But one common word can be stressed for all: unless the soldier has particular warning about specific tribes, he can expect assistance from natives in time of emergency. They are inclined to be helpful, either out of courtesy, or fear, or hope of reward--more so since the tide has turned to the side of the Allies. Some have had sufficient comparative experience with Japanese and Americans to have a specific preference. Some can be expected to give help to soldiers of either side. Very few are expected to act solely for the Japanese; some may refuse out of fear to help Americans, if they are too close to Japanese installations (although an American flyer forced down within ten miles of Jap-held Rekata Bay was gladly escorted to safety by natives). Native attitudes are further complicated by the extent of Japanese penetration. Many Japanese colonists were sent to the mandated Micronesian islands, such as the Caroline and Palau Islands. There is little recent information available on the attitudes of peoples formerly considered friendly.

It is true that in the Malay peninsula compaign and in Burma many of the local people gave aid to the invading Japanese, probably out of a dislike of the British, and also, fear. Reports seem reliable that these same natives would now prefer the Allies to their new "Collaborators" in the co-prosperity sphere, and, if treated properly, would help Allied soldiers in trouble.

IV. POLYNESIA

This area (the name means "many islands") contains the eastern portion of the Pacific islands. It includes the Society Islands (the most famous is Tahiti), the Samoan group (the town Pago Pago is on the island Tutuila) the Line Islands, the Cook Islands, the Tuamotus, the Australs, the Marquesas, and, at the meeting point of Polynesia, Melanesia, and Micronesia, the Ellice Islands. New Zealand, far to the south, has as the native population the Maoris, a Polynesian people. The Hawaiian Islands, although north of the smaller islands, are considered part of the Polynesian group, although the Polynesian inhabitants are by now considerably outnumbered by mixtures of Japanese, Chinese, native Hawaiians, and others.

A. Development and Appearance

The inhabitants of these groups are universally friendly to Allied interests, having been for some time in the sphere of Allied control; the French Society Islands repudiated Vichy quickly. The Polynesians are as a group the farthest advanced of all Pacific peoples.

They are the most adventurous and ingenious, having navigated farthest to reach their final homes. Their exploits in traveling thousands of miles in open boats, with families and possessions, are part of a proud tradition. Their attitude toward white visitors is to take them at face value, as equals, and to condemn equally arrogance and servility. They are fully acquainted with white ways, and have assimilated many European and American habits.

In physical characteristics, they are the tallest and probably the healthiest of the South Sea islanders. They are fairly lightskinned, with a yellowish tinge. Their eyes are large, brown, and straight, without the eye-fold on the inner corner which is the distinguishing mark of the "yellow" race. Their hair is black and straight or wavy. They have a tendency toward corpulence with increasing age. In general their appearance is closest to that of the white race.

B. Learn from Them

Soldiers stationed on a Polynesian island should take advantage of the opportunity of learning as much as they can from the cooperative and friendly natives. There is much of value in the fields of fishing and hunting, making shelters, using native plants for food, that can be more easily picked up from Polynesians than from more backward groups. There is always the chance that soldiers will be sent to a more advanced base.

Most of the natives are likely to have an acquaintance with either French or English in addition to their own language. Soldiers are encouraged to learn as much as they can about the native language, because, despite the variety in dialect within the Polynesian tongue, there is a good chance that many basic expressions will be understood throughout the Polynesian area. English is understood widely in the Cook, Samoan, Tongan, and New Zealand groups, and French in the Marquesas, Society group, and Tuamotus.

C. Details on Polynesian Manner of Living

1. Subsistence: Yams, taro, breadfruit, bananas, and the sago palm are important. Fishing and some hunting. Pig and dog are the only domestic animals.

2. Stimulants: Kava is widely drunk. Betel nut chewing with lime is a common practice in the western Polynesian islands; the habit stains the teeth a coal black and colors the spit bright red.

3. Crafts: Pottery, wood carving, wooden dishes; no metals in native crafts; bark cloth; bamboo tools; mats, baskets. Clubs and spears are elaborately carved. Warfare is surrounded with elaborate religious observances.

4. Clothing: Men wear the loin cloth; women wear knee length skirt. Tapa bark cloth is highly decorated, and more widely used than in other island areas. Elaborate body and face tattooing, as indication of social status, is dying out. Little scarification.

5. Ornaments: Less common than in other island groups. Wide use of fans.

6. Transportation: Poles carried on shoulders, dugout canoes, single and double outrigger canoes, and canoes equipped with sails. Multiple canoes with platforms to carry weight.

7. Religion: Normally Christian, but many traces of old religion based on concepts of Mana and tapu (tabu) underlie religious and social organization. Priesthood and reverence for ancestors highly developed.

8. Government: Chief, with tendency to absolute power. Also village council. Often dual chieftainship: one rules, another considered sacred.

9. Houses: Both dwellings and religious buildings of wood, with thatch or matting roofs and sides. Stone rarely used. Stone "maraes" or small pyramids used in religious ceremonies.

10. Rank: Based on descent and seniority of birth. Divisions into sacred chiefs, ruling chiefs, priests, commoners, and slaves. Rank has religious sanction, based on ancestor worship.

V. MELANESIA

This is the theatre of present fighting in the Pacific. The Solomons, New Guinea, New Britain, New Ireland, New Hebrides, and the hundreds of smaller islands, which keep breaking into print as the Australians and Americans advance, are inhabited by peoples less socially advanced than the Polynesians. The term Melanesia means "black island area", in reference to the dark skin of the inhabitants. The skin is not black, but rather a chocolate brown. The degree of negroid characteristics differs in various areas: broad nose, thick lips, curly or woolly hair. There is no uniform physical type.

A. New Guinea Types

There are three general types in New Guinea: the "true" Melanesians, the Papuans, and the pygmies, or Negrites. The first group is found in the area where our soldiers are now fighting: north and east coastal New Guinea, and the Solomons. The people are evidently greatly mixed, but the same general tendency in all the Pacific obtains: natives farther north and east have longer and less woolly hair, narrower nose, and lighter skin. The body might be decorated by tattooing, scarring, or punching holes through nose and ears for rings and pins. The "Melanesians" are in the main longer-headed than the Papuans, have smaller noses, and are likely to have less pronounced brow-ridges.

The Papuans ("woolly hair") are likely to have Negro features, but there are strains that suggest immigration from southern Asia and India. Western New Guinea, the home of the Papuans, lies on the migration road. Hair in this section is shorter than in the east. The men pierce their nostrils and ears, but scarring the body is usually limited to women.

The interior of New Guinea is inhabited by Papuans, Melanesians, and Negritos. Some hostility to strangers is still evidenced by the inland tribes. The pygmies are especially shy, as would be expected from a marginal race hanging on to existence in less desirable land areas, but they are usually amenable to a fair and friendly approach.

B. Important Melanesian Areas

New Guinea, with its tough ridges of mountains and its steaming jungle, is well known to us through the accounts of the Australian-

American task force advance across the Owen Stanley range, and the slow advance through Gona, Buna, Salamaua and Lae. All these operations took place in the southeastern peninsula, part of the area called Papua (notice that the people called Papuans live both in this section, and in the west). The northern and eastern portion of the island is the British territory, while the Western half of the island, with its "bird-head" peninsula, the Vogelkop, is Dutch. The Japanese have a thin hold on the coast, but the main territory is untouched by war, except possibly by planes coming down. The natives are likely, then, to be of aid to soldiers who come among them, without fear of Jap reprisal.

Rabaul, the main Japanese shipping and bombing base, and the main target of Army Air Force heavy bombers, is a town on the northeast corner of New Britain, a long island east of British New Guinea, in the Bismarck Archipelago. We shall hear more of this island, and its natives, as operations increase with the approach of Allied soldiers up the New Guinea coast and through the Solomons.

New Caledonia is a way-station for personnel in the Southwestern Pacific theatre, and was the jumping-off place for our attack on Guadalcanal, being equally south of the Solomons and east of Australia. The native population, completely accustomed to outside influence, had been before the war reduced to less than half of the total inhabitants, who include whites, Japanese, and Indo-Chinese.

The Solomons, including Guadalcanal, New Georgia, Choiseul, and Bougainville, have a climate that is not considered healthful for Europeans. Humidity and heat are excessive, and malaria is everywhere, as our men have found out. Dysentery is also common. The natives are Melanesians, much intermixed. On Bougainville, the northernmost of the group, they are very black. The coastal natives are inclined to be f friendly to our side, and have proved their dislike of the Japanese. Until recently cannibalism was common in the islands, and may still exist on a small scale, along with head-hunting. Pidgin English is widely understood.

C. Details on Manner of Living

1. Subsistence: Much like Polynesians.
2. Stimulants: Kava and betel nut.
3. Crafts: Pottery, woodcarving. Wooden dishes, drums. Twirling stick to produce fire. No metals. Bark cloth. Bamboo tools. Mats, baskets.
4. Clothing: Men wear loin cloth; women wear knee-length skirt. Tattooing and scarification.
5. Ornaments: Shell, bone, teeth pendants. Elaborate combs and other hair ornaments.
6. Weapons: Clubs, spears, bows and arrows, slings.
7. Transportation; Poles carried on shoulders, dugout canoes, single and double outrigger canoes. "Lakatoi" canoe--four or more dugouts lashed together and platform placed on top. Will carry tons of weight.
8. Religion: "Mana," a mystical force which is source of all power. Belief in friendly and hostile spirits.
9. Government: No tribal chief but control in each village is in hands of a local chief and old men.
10. Houses: Rectangular and circular thatch houses. Some tree houses, sacred houses and communal houses over 400 feet long.

VI. MICRONESIA

Most of these islands, of which the largest is only 12 by 15 miles, have received the benefits of Japanese guidance since 1920, the inception of the League mandate. They are scattered over a wide area north of the Melanesian string. Japan jealously kept other nations from contact with these islands. From west to East are the Palau cluster, the Caroline string, and the Marshall group. Southeast of the Marshalls, and near the imaginary juncture of Melanesia, Polynesia, and Micronesia, are the Gilbert Islands, formerly owned by Britain, but since taken by the Japs. Our task forces and bombers have attacked Tarawa and Makin in this group.

We can be sure that the Japanese have extensive naval, air, and military bases in these islands. Truk, in the Carolines, is supposed to be the strongest naval base in the Pacific outside of Pearl Harbor. It is really a cluster of small islands huddled within a barrier reef about 40 miles in diameter. Yap, about a thousand miles west of Truk, is a base of the San Francisco-Shanghai cable, which has a branch from Yap to the Netherland Indies. Ponape, 400 miles east of Truk, is the largest island in the mandate. Unlike most of the islands, it is rugged and mountainous. On its north side there is a cluster of small islands affording anchorage to the Jap fleet. Guam, east of the Philippines and south of Tokyo, was under U. S. mandate before its capture.

Most of the islands are low, of coral structure, and very small. Many are uninhabited. The people are Micronesian hybrids, with Melanesian mixture, especially in the west, as in Palau. They are good agriculturists, canoe-builders, and navigators. Throughout the islands the natives have in the past been friendly. But we cannot know what effect the Japanese may have had on them. Further, we can assume that the number of Japs themselves in the islands has greatly increased; the process started before the war. Pidgin English is understood in the Carolines, Gilberts, and Marshalls. The survival procedures outlined in another lecture will apply to these islands, except, of course, the advice to throw oneself into the hands of the natives.

VII. MALAYSIA

Malaysia extends from the Malay peninsula to the borders of New Guinea and from the southern coasts of Sumatra and Java to the northern part of Formosa. It includes the following:

Malay peninsula
Andaman Islands
Sumatra, Java, Bali, Sumbawa and Timor
The Celebes group
Borneo
Philippines
Formosa and smaller adjacent islands

The physiography is largely volcanic. In late glacial times the area was connected to the Asiatic mainland by a series of land bridges which allowed for the movement of plants, animals and man. The climate

is tropical, vegetation is luxuriant, and annual rainfall averages more than 100 inches, as compared with 38 at Key West, Florida, and 43 in New York City.

Malaysia was the theatre of the first Japanese campaigns and today the Japs are in more or less firm control of the entire area. Although the natives of the islands are likely to be friendly there is constant danger of encountering enemy soldiers.

A. Malaysian Types

The population of the region consists of various groups of Malays, Indonesians, and Negritos. The Malay is the most recent immigrant to the islands and is by far the most numerous, most advanced, and most widespread. Typical Malay peoples are the Sakai of the Malay Peninsula, the Batak and Menang Kabau of Sumatra, Bontoc, Igorot and Tinguan of the Philippines, and the Filipino. In physical appearance the Malay is short, of slight build, round headed, with straight black hair and yellow-brown skin.

The Indonesian, or Proto-Malay type, is found in every part of the archipelago thoroughly fused with the typical Malay. Typical peoples are the Jakun of the Malay Peninsula and the Dyak of Borneo. Features like long heads, wavy and curly hair, stocky body build, broader noses, and darker skin help to distinguish them from the Malay, but this must not be interpreted to mean that there are any true "Indonesian" tribes.

The Negrito, the earliest immigrant to the islands, is widely distributed but is the least numerous of the physical types. They are characterized by very short stature, an average of only 4 ft. 10 in. for adult men. Pressure from the more numerous Malay have driven them into the interior regions of the Andaman Islands, Malay Peninsula and the Philippines. Typical Negrito people are the Semang of the Malay Peninsula, the Andaman Islanders, and the Negrito of the Philippines. They live in scattered bands usually in the forested mountains and in their living make use of many items borrowed from the surrounding Malay. Their mode of life is exceedingly primitive and they are antagonistic to outsiders.

B. Details on Malaysian Manner of Living

The modes of living, customs, mannerisms and habits, differ from island to island and no general pattern of life can be said to hold for the entire area. Upon an underlying Malaysian core there have been pyramided items borrowed from a multitude of sources, including India, and China, with influences from Mohammedanism, Spanish-Catholic, Dutch, British and American policies, and Japanese migration and policy. Customs and habits most widespread among the Malay, the people the American soldier is most likely to meet with, are as follows:

1. Cultivation of rice. This is the staple food. Look for rice terraces.
2. Houses are of thatch, gabled and raised from ground. Houses built in trees are common. Long houses prominent.

3. Tattooing common throughout Malaysia. In the Philippines it is connected with head-hunting. Blackening of teeth from betel nut chewing is widespread.
4. Iron working is universal. Cylindrical bellows and native forge permit the making of highly tempered axes and knives.
5. Typical weapons are the kris, iron-pointed spear and blow-gun.
6. Vestiges of headhunting are found on some of the islands; it is, combined with ceremonial cannibalism, in which parts of the enemy's body are eaten, to gain his power.
7. Religion consists of a cult of ancestral spirits. People talk to spirits through mediums, spirit houses are built, and many ceremonies are connected with the mediums.
8. Government is for the most part local. Each village selects one of its old men to act as its head but he has little actual power. Custom is the law.

Malay is the common language of most of the islands. It is an easy language, and a minimum vocabulary should be learned by every soldier stationed in the area. In ordinary times most natives preferred Dutch money; the soldier should also remember that they are particularly fond of cotton cloth, combs and wrist ornaments.

VIII. AUSTRALIA

The island-continent is off the beaten path of migration, and as a result there is less mixture in the native population. The characteristics of the Australian bushman are coarse features, heavy brows, well developed beards with straight or wavy hair. Only in northern Australia, around Port Darwin, are natives likely to be met by American soldiers in any numbers. Pictures in Yank have shown air crews hobnobbing with the bushmen. The natives are friendly, and under the control of local authorities.

The bushman's life is simple, with few material possessions, but he has a complex religious and social life. Happiness and contentment are measured in terms of family life and religious observances, rather than in material things. The number of natives is small, and they are scattered over immense areas in arid central Australia. They eat what the soil has to offer of roots, berries, plants, insects, animal and bird life. Vegetation and animal life are scanty; this necessitates constant moving about. Little or no clothing is worn. The only domesticated animal is the dingo, a kind of wild dog. Crude windbreaks, rather than houses, are used as shelter against rain, wind, and cold. Tools and implements are mainly of stone; and the only weapons are the boomerang and a crude spear. Baskets are used, but there are no metal or clay containers.

An important thing to remember about the Australian bushman is his remarkable knowledge of animals, plants, sources or water, and the lay of the land in which he lives. He is likely to be the safest guide in an emergency.

IX. HOW TO DEAL WITH NATIVES

You have been hearing repeated sermons on the need to treat the natives right. Your question in return might be, "But exactly how is this managed? How can we know what they expect?"

A. Attitude of Curiosity

First and most important is the matter of attitude. If you are stationed anywhere in the Pacific area, you are likely to have some contact with local populations. You must try to find out what their customs are, what their general feeling towards things is. Don't be like the New York boy who decided Chicago was a hick town because it didn't have a subway. He judged everything by his own narrow standards. Some day your life may depend on the proper approach to natives. It would be wise to start learning about them as soon as possible.

As soon as you reach your station, start learning. First, learn a few of the spoken words and phrases of the local tribe. It may be akin to the tongue spoken in another area, where you might need help; it is a way of showing respect to the people, and they will respond; it will give you a key to how the people think; it is a step toward learning other things.

Then, take little escorted trips over the country. Have a native give you names of various plants and trees. Visit the gardens and cultivated patches, so that you can recognize food plants, and ask for them by name. Learn some of the characteristics of the local forest from the natives: other jungle may not be similar, but there is a good chance that what you know about one area can be applied elsewhere. Do not forget to pay your guide. Learn, locally, the current established rate of payment.

B. Making Contact

If you ever have to ask help from the natives, you must get yourself into the frame of mind that shows neither fear, nor superiority. Ask for help the way you would ask an independent garage owner for help with your tire--as if it were a cooperative venture you are to work out together, even though he will do the major part of the work.

Do not force physical contact upon the natives. They do not like to be pushed around any more than you do. If they offer a handshake, good: but do not take the liberty of patting them condescendingly on head or shoulder. The best thing is a cordial smile, a welcoming gesture of the hand. You must not be reserved and subtle in your gestures. Communication is the important thing. One pilot got hiding natives to converse with him by holding out a large branch, breaking it in two, and placing it on the ground. There is no established way of making contact, however. Once natives tried to find the allegiance of a pilot who asked for help. They showed him a Japanese flag; he held his nose and motioned it away. They showed him a picture of Churchill; he smiled, but shook his head. They showed him a picture of Roosevelt; he smiled vigorously and motioned to himself. They were delighted. Of course, not all natives are likely to have such stage props. But is would be a good idea to carry a small American flag along on missions.

C. Money and Objects of Value

In some areas the people are sufficiently acquainted with white people to be able to differentiate between national currencies. Hard money is generally more valued than paper money—as one would expect. Some natives will even accept a note, or chit, from an airman they help, expecting the note to be honored when they run into an American camp. But most would prefer to be paid in their own medium of exchange. In New Guinea, especially inland, a sea-shell called the cowrie is valued. Acceptance of these shells is surprisingly wide-spread. Their value increases with the distance from the coast. It would be good to collect a number of them, and tuck them away in a pocket of the flying suit. They are flattish, oval, usually white and glossy, but certain orange species are highly prized, in the Fijis, for example. Another valuable commodity is salt. Carry a couple of ounces in a waterproof container, both for your own use and as a gift for natives.

The usefulness of a sharp cutting surface is apparent. There seems to be universal appreciation of the gift of a razorblade, the shinier the better. Soldiers are advised to have some blades along with them at all times—in a moisture proof packet, of course. One should never take any fruit or vegetables from a cultivated patch--if you have to--without leaving some payment. A blade left in a conspicuous spot is advised by veterans of jungle operations.

Of course, knives, daggers, and other metal will be appreciated. For primitive peoples still in a stone age culture, as many tribes are in the New Guinea hinterland, metal is wonderful. One of the few dangerous tribes in New Guinea, the Kukukuku, are supposed to have killed prospectors, taken their shovels, and in some way managed to cut these into narrow strips for knives.

Other natives value shiny tin cans. One can understand how these will be prized as cooking utensils. Do not throw out your ration C tins. Keep them around: you may have to cook out of them yourselves, or be able to use them in trade with natives.

One officer found his way into the approval of natives by offering them his collar insignia of bar and wings. Jewelry seems to have a natural attraction for most people; and recently a magazine carried a full-page picture of a pile of cheap jewelry, G. I., for use in dealing with Pacific natives. There is no way to know ahead of time what might meet the fancy of the people you run into. This must be learned on the spot.

But the important thing is to consider the ways of the natives and adapt yourself to them. If they want to take their time about doing a job; if they travel more slowly than you would like; if they laugh at something you do not think funny--there is little you can do about it. You can indicate impatience, and that might hustle them along; but swearing or, worst of all, physical force, might be dangerous. And again, the more you know about the natives, and the earlier, the better.

X. DO'S AND DON'TS IN RELATIONS WITH NATIVES

1. DON'T take a superior attitude. The natives have an intense personal and group pride, and think well of themselves and their way of living. A Polynesian can trace his ancestry back for 600 years and more, and could with justice scorn our DAR'S, FFV'S, and Mayflower descendants.
2. DON'T consider the native "funny." You seem a good deal funnier to him, but he may be too polite to show it.
3. DON'T be aloof and superior, but on the other hand don't try to get too intimate. Most natives have an intense personal dignity, and maintain reserve. Do not slap people on the back.
4. DON'T ever laugh at the natives; laugh with them at the mistakes you make.
5. DON'T be loud-mouthed and noisy; that is bad manners anywhere.
6. DON'T intrude on dances, rituals, or other ceremonies unless you are invited.
7. DON'T intrude in temples or sacred areas.
8. DON'T take sides in native disputes, or show favoritism to one group over another.
9. DON'T be destructive of plants, animals, or any other property. They belong either to a person or to the community.
10. DON'T make advances to the native women. They may not wear much clothing, but they have a code of modesty at least as rigid as that of the girls back home; and they belong to someone else.
11. DON'T appear afraid or suspicious, even if you believe there is good reason to be. Be polite and dignified, and smile.

1. Take it easy; go slow in your relations with natives. You can tell from their reactions whether you have made a mistake.
2. Learn the rules of etiquette for greetings and table manners. Natives may eat with their hands, but they have codes and ceremonies just the same.
3. Keep your word if you make a promise.
4. Pay for things and services you use, either in money or with presents.
5. Remember that you appear as curious to the natives as they do to you. They are interested in knowing what things are like where you come from. Show them pictures and illustrated magazines of life in America.
6. Show respect and politeness to all natives, and especially to chiefs, old people, and local leaders.

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NINE SCHOOL LECTURES

THE TROPICS (THREE LECTURES)

T-II LECTURE II—PERSONAL CARE, AIRCRAFT MAINTENANCE, AND ELECTRONIC EQUIPMENT

Prepared by

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* * *
School Lectures

THE TROPICS

Lecture II:
Personal Care, Aircraft Maintenance, and Electronic Equipment

Part I--PERSONAL CARE

I. TRAINING AND PERSONAL EFFICIENCY

The Japanese trained for months on Hainan Island back in 1941 for their attack on Malaya, Sumatra, Java, New Guinea, and the other tropical areas they swallowed so quickly. They practiced camping, living, bivouacking, marching, infiltrating. They rehearsed landing operations over and over. Those men who proved unequal to jungle work were weeded out. No one can deny that this training was effective. It was so effective that our own leaders realized the Japanese could not be pushed back and routed out if our own soldiers were not just as well trained and hardened to "the toughest fighting in the world". Schools and training camps were set up behind the lines in India, Burma, New Guinea and other islands, and proof that our men are responding magnificently to their schooling appears in the battle reports every day. Our men are now beating the Japanese at their own game.

A. Importance of Individual Health

All this personal and tactical training is also operational and maintenance training. The Japanese based their training on a correct principle: tropical operation depends not primarily on equipment, not even primarily on personal courage; but on physical preparedness, and personal maintenance. If the men are in condition, the machines will be in condition. If the men are ill and weary; if they have diarrhea and malaria and leech sores and fungus parasites, they cannot take care of the machines, and they cannot fight jungle warfare, either on the ground or from the air.

1. Physical Conditions

The initiation of a military plan may depend on how many men are "effective" for active operations; the number of men may depend on the correct use of mosquito nets or atabrine or water purifier.

The Japanese knew that the danger of mechanical breakdown lay not primarily in natural factors, such as engine starting temperatures, as in the arctic, or abrasion and short life of vital parts, as in the desert. They knew that weapon and airplane maintenance depend on maintenance of health and spirit.

Not that the tropics, apart from the problem of personal health, are a pilot's or a crew chief's paradise. There is the problem of humidity, which penetrates and rots; corrodes metal equipment; makes fields and landing strips difficult to keep drained; creates bogs and slippery, treacherous surfaces; and encourages the jungle to grow back at appalling speed. Troops have to dry and oil every part of their weapons every day. Line crews have to be alert for rust and rot. Radio operators have to worry about batteries, semi-enclosed connections, and all the parts that can be harmed by moisture, fungus growths, and insects. This will be discussed later.

2. Mental Health

The broad picture is of the struggle against deterioration in men, and in the implements of daily living. This picture includes not only details of physical health, and care of equipment. It involves also a psychological preparation for the peculiar nature of jungle war: small units stalking each other; narrow trails; ambush; night attacks; surprise and sudden death. The British fought bravely on the agonizing retreat down the Malayan peninsula--when they could fight. But they just did not know the tricks; they stumbled backward blindly, not quite demoralized, but unprepared to meet the Japanese in the new tactics. It is no secret that many of our men on Guadalcanal broke down under the night attacks, interruption of sleep, bad sanitation, and illness; many developed "combat neurosis". They were fine lads, but they were not prepared for what they had to face. More recently the picture is completely different: our men and the Australians have been infiltrating masterfully behind Japanese positions, and are pushing the Japanese back in the tense jungle stalking. Their training, both hygienic and tactical, has "taken".

Does all this apply to Air Force men--pilots, air crews, ground crews? Yes. In the jungle, everyone fights, not merely with planes, but with rifles and pistols and tommy guns. Even in those parts of the tropics which are not jungle, and behind the lines, there is still the need for rigorous health precautions. How much each man will be responsible for depends on the station: third echelon personnel will not normally have to worry about the supply and the purity of their food and water, but may still have to keep alert for fly and mosquito infection. In a front line combat unit, each man will have great individual responsibilities.

II. RULES AND PRECAUTIONS

The problem is: how can the human machine be made to work efficiently under tropical conditions and the conditions of modern warfare? Certain simple rules must be followed with the same regularity and habitual ease with which one puts on pants and necktie in civilian life. (1) We must protect ourselves against malarial mosquitoes. (2) We must not drink bad water. (3) We must care for insect bites and skin wounds.

Other more general warnings are: (1) We must eat properly, or the best we can; (2) we must try to rest adequately; (3) we must stay clean and obey strictly all sanitary rules; (4) we must avoid undue fear and worry; (5) we must keep in mind the objective, and maintain an enthusiasm for the job; (6) we must have and use breaks and longer periods of relaxation.

These cautions bring in the important matter of personal equipment: (1) We must use mosquito netting; (2) we must know what to use to purify water; (3) we must have and use the right clothing. This must not be left to officers and non-coms, any more than you would leave to them your decisions when to urinate. Mosquitoes and clothing are your own personal affair. It is your life which is at stake, and also the lives of the men in your unit. If you become ill you are useless, and other men have to protect and wait upon you.

This preparedness and training is closely related to survival in an emergency--in case you are lost during a march, or after a force-down or bail-out. These matters will be discussed more fully in the next lecture, but you must realize now that you save yourself in an emergency by the training you have every day, until the acquired skills are needed. If you know how to avoid being bitten in camp or on maneuvers you will do pretty well in the wild alone.

III. THREE PROBLEMS

A. Avoiding Mosquito-Borne Diseases

Why mosquito netting? Rear Admiral Ross McIntire, Chief of the Bureau of Medicine and Surgery, and other authorities say malaria is the most serious medical problem of the war; in fact, the No. 1 source of casualties. Wherever the Navy or Marine Corps lands, there are CB units assigned the task of mosquito-proofing the area, if the task is at all possible. They help choose sites for the camp, they disinfect or oil up patches of still water, they enforce mosquito discipline. The best sites are on high and open ground, at least one-half mile, if possible, from water, with the wind toward the water, to discourage flight of mosquitoes to the camp. Mosquitoes can breed and live at least a mile above sea-level, if water is available, so troops away from the lowlands should not think they are free from danger. Also, different kinds of mosquitoes breed differently --some in fresh, some in brackish, some in still, some in moving water.

1. Protection by Cover

Men should try to get under cover--behind screening--by nightfall. The main flight of the anopheles mosquito is from shortly after sundown to about three or four hours later; also about sunrise. They may also attack by day inside houses and in the dim, thick forest. If we are required to walk in the open after dark, especially during this period, we should be sure to cover up with headnet, long sleeves and trousers, and gloves. Marines who fought on Guadalcanal believe that flannel gloves for protection against insects while sleeping would have been useful equipment. Gloves are now G.I.

Native habitations may be curious, and soldiers may desire to show their friendliness toward the people by visiting them, but this may be fatal. Stay away from native huts at night, especially during early evening. Anopheles mosquitoes are not malaria carriers until they have bitten an infected human being--and most native peoples are pretty sure to carry the infection. Therefore the proportion of disease-carrying mosquitoes is likely to be highest within a settlement and for a radius of a mile around. Other

kinds of mosquitoes carry diseases, too. The culex mosquito, related to the kind we encounter at home, where it usually does no more damage than a buzz and a bump, can cause a painful and unpleasant disease, filariasis. Its bite injects larvae of minute worms, which cause a swelling of the scrotum and legs, or block circulation in other parts of the body. The aedes mosquito can cause dengue (breakbone) fever, or yellow fever. So you have to beware of more than the small malarial mosquito, or anopheles, which bites you from a slanting position. Avoid them all. Kill them all. They are more dangerous than Nips.

Use mosquito spray, or an insecticide bomb, generously in any shelter. That includes a slit trench; also spray the inside of airplanes, both to prevent infection and to prevent transfer of disease-bearing mosquitoes to other areas.

Be sure that your sleeping net or head net does not touch your skin. Where the net hugs, so can a mosquito. Tuck the net well in under your roll or blanket. If you have no protection, stay near a smoke fire.

There are new mosquito-repellent lotions issued to troops. These should be used in the quantity and at the times directed. But they are only partial measures, and cannot be depended on to prevent all bites. Do not depend on any fancied aversion you think mosquitoes have toward your skin. Tropical mosquitoes are much less particular than the Jersey breed.

2. Tablets

Quinine and atabrine tablets do not prevent malarial infection, but they may reduce the effect, and keep dormant the symptoms for a number of days, and allow men to carry on their mission adequately without time out for chills and fever. A flyer took his atabrine tablets regularly while being carried back to camp with a wounded leg, sustained while bailing out of a burning plane. The full effects of malaria hit him three weeks later, when he was under expert medical care. If malaria had been added to his other disabilities while making his way back, he would probably not have been alive more than a week. A lieutenant colonel of Marines declared, "We did not start taking quinine and atabrine soon enough when we hit Guadalcanal. We are paying for this now." These medicines are indispensable.

B. Drinking Water, Food and Disease

Rain water directly caught in clean containers is likely to be safe. Artesian well water from below rock strata is safe until delivery to the surface, unless the well is contaminated. But water from streams, water from shallow wells, water taken anywhere near native houses should be considered dangerous. The stream may be fast-flowing and clear; but it may still abound in flukes and other parasite worms, or germs carried down from an upstream native village. Water found anywhere near where natives live is likely to be polluted. They have few ideas of sanitation, and even if it were explained, it would take time for so new a set of principles to sink in. For one thing, their immunity is greater to local diseases than that of white men; if they do become ill, it is likely to be less seriously than if we were to contract the disease. Those individuals who might have been highly susceptible to intestinal disease have been killed off long since; they were the "unfit"--the "fit" have survived.

The simplest treatment for water is boiling. About five minutes is a safe length of time for boiling at sea level. In the field there may not be enough time to boil water properly. In this event halazone tablets can be expected to take care of about nine-tenths of possibly dangerous organisms in water. If the solution of a single tablet per quart does not cause the water to smell and taste slightly of chlorine, after standing 30 minutes, another tablet is needed. The tablets do not kill the eggs and larvae of round worms and flukes; therefore the water must be carefully filtered before purification. In a pinch, a drop or two of iodine may be used to purify water, but you need not be told that iodine water requires much getting used to.

Dysentery, typhoid, para-typhoid, and cholera germs all come from the intestines of some person who has had the disease, and spread by the careless disposal of body waste. Heavy rain washes contaminated soil into streams, which are used for drinking, and the disease spreads.

Vaccination cannot be depended on to protect fully against large numbers of typhoid, para-typhoid and cholera germs. Water and food precautions are the absolute requirement to protect against these diseases. Avoid unsterilized water, raw vegetables, such as salad greens, radishes, etc.

Flies breed in filth and garbage, and spread germs wherever they walk. It has been proved in hundreds of army camps: dysentery goes down when screens go up. Screen mess halls, kitchens, latrines, and keep food covered.

C. Avoiding and Controlling other Insects and Pests

The greatest annoyance and, next to malaria, the most serious danger in the tropics is the attack of insects or other small organisms. The body surface should be examined periodically, at least once a day, for various kinds of creatures. Avoid infection from bites, cuts, and scratches by prompt and proper action.

1. Ticks

Ticks can transmit relapsing fever and typhus, and can cause skin infection even if they are not germ carriers. The several kinds of ticks all suck blood by burrowing the head into the skin. They may be present in the clothing for hours before they attach themselves to the skin. During this time they are very annoying as they crawl over the skin; thence the need for frequent inspection. If they have caught hold of the skin, they should not be squashed. A covering of saliva or iodine, or a lit cigarette, held near, without touching them, may cause them to let go, and then they can be gently lifted off. Iodine or alcohol will prevent skin infection from the bite. If removed early after attachment, the head does not become deeply imbedded. A tick, once infected by sucking the blood of a diseased person, can carry relapsing fever throughout its life.

2. Other Insects

Sand flies, fleas, and lice can cause various diseases, including several kinds of fever and plague. Do not rub or scratch a bite; this either

irritates the skin, causing a slow-healing sore, or actually rubs the poisonous feces of the insect into the skin. To reduce danger of infection from scratching during sleep, keep nails trimmed and clean. The general rules are: (1) Do not scratch! (2) Swab with alcohol or iodine. (3) Stay away from native huts and shops, and pets and cattle owned by natives. (4) If possible, locate camp away from where there are numbers of animals.

3. Leeches

Leeches are another possibility. They have a way of working through small openings in the clothing--rips, buttonholes, fly openings--and attaching themselves to the body without being noticed. They cause no pain while attaching their suckers and drawing blood, but exude an enzyme which prevents blood from clotting, so it flows freely. Again, do not pull them off: their sucking apparatus will take bits of skin along, and leave an opening for probable infection. A drop of iodine, a pinch of salt, tobacco juice, a lit cigarette, or a hot stone will make them let go. Apply iodine or another antiseptic, and do not scratch. Cover with a band-aid. Whenever you have brushed past a wet tree or bush, take a quick glance over your clothing or make inspections during breaks.

4. Flukeworm Parasites

Quiet jungle pools will look inviting after a sweaty march, but do not take a dip in fresh water which has not been inspected, or about which you have no general instructions. The probability is that the water is harmless for bathing, but wait for the word of the medical officer. Round worms and flukes, tiny, almost invisible parasites, have a way of finding body cavities and making themselves at home. They may produce either urinary or intestinal schistosomiasis, also called bilharziasis. Young forms of these flukes can enter the body through the unbroken skin, as well as in contaminated drinking water. Water along the East and South Asiatic coast, in Southwest Pacific and West Indies islands, contains organisms of these parasitic types. They are harbored during one stage of their life cycle by certain species of fresh water snails. When the flukes leave the snail, they die in forty-eight hours if they do not find another host. Therefore, water can be used for bathing if it has been set aside in a clean container for a couple of days.

5. Fungus

A special affliction for the unclean and lazy, although not restricted to them, is fungus, a plant growth that attacks and thrives on the skin. Dhobie's itch (or trichosporosis) gets in your hair; athlete's foot in the tropics is like nothing you ever got playing tennis. The body must be kept as clean and as dry as possible. If there is not enough clean water available for a complete bath, at least those parts where sweating occurs--armpits, groin, and feet--must be washed with soap and water, rinsed, and carefully dried. Foot-powder, a drying agent, is helpful. Some soldiers consider it indispensable. Socks should be changed and washed as often as possible; and at least every day. Light wool socks have been found best for use in hot climates. Cotton socks have caused infection. It is helpful to add to the water bath the right length of sun-bathing, followed by a rubdown with a clean cloth.

D. Medical Kit

The contents of one's personal medical kit become important when viewed in connection with the above mentioned possibilities. Of course, in an existence centered around a stable camp, where there is not likely to be much moving off on one's own, the central dispensary will be the station for some of this material. But it is wise for every soldier to know the use of the following ordinary components of the individual tropical medical kit, as listed in the Basic Field Manual, FM 31-20: a jungle food bag, rubber-lined; athlete's foot solution; water purification tablets; 2% tincture of iodine; sulfadiazine; atabrine; first-aid packet; adhesive tape; insect repellent; salt tablets; aspirin; adhesive gauze bandage; foot powder; all in a waterproof duck roll. Notice, these items are not considered only as part of an emergency kit. They may be necessary for so short and so ordinary an operation as an easy day's march away from camp.

IV. HEAT AND ACCLIMATIZATION

The body has the never-ending job of keeping its temperature down. Evaporation of sweat is the most important means of getting rid of excess heat. Humid air, therefore, already containing a great deal of water, slows down evaporation of sweat, causing discomfort.

Men must get used to being warm, with little relief. "Acclimatization" is the process of getting used to working and sleeping under new climatic conditions. This should be done gradually: men must rest more than ordinarily, and drink more water at first. Later the body can adjust to a normal working and resting schedule. The process may take from a week to a month, depending on the individual.

Heat accumulation can result in mere loss of efficiency or alertness, or, if the disturbance of the balance between heat production and heat loss is sudden, as the effect of working in hot sun, the result may be heat stroke. In this case the body must be cooled quickly, with cold water, wet clothing, ice, and fanning.

Heat cramps and heat exhaustion both result from another cause, the lack of enough salt in the body. Sweating removes salt from the body; the salt must be replaced. If not enough salt is taken in food or in water, the body may experience sharp pains, or worse, a condition resembling shock--chills, cold sweat, fainting. The treatment is the giving of salt in water.

Some rules on protection against the heat:

a. Keep in the shade as much as possible, and protect the head from hot sun.
b. Try to find a breeze; at least wear loose clothing.
c. Do heavy work smoothly, avoiding sudden strain.
d. Drink as much water as possible, to induce sweating in great heat.
e. Take extra salt; it is better in food or water than in tablet form, which is hard for some men to take.
f. Get as much rest as possible.
g. Regular exercise keeps the body toned up.

V. CLOTHING AND EQUIPMENT

What to wear in the tropics? A discussion of what to wear, and when, must be governed by the facts on protection against disease, minor scratches and bruises, etc. It is important to have clothing available which will help guard against insects, and injuries, besides being comfortable. We have seen many pictures of our boys in the Solomons and New Guinea stripped to the waist and finely tanned. But we must notice that these are daylight pictures and the boys were at rest, soaking up sunshine. They were in a clearing, either on an airfield or an open road. During jungle movements, and at night, the men keep their shirts on and they keep well buttoned up at waists and ankles. This helps keep out ticks and leeches, as well as protect against mosquitoes and scratches. High shoes with bellows tongues are advisable against leeches. But no protection in itself is sufficient; there must also be inspection and cleansing.

A. Shoes

Leather becomes moldy pretty quickly, and there seems to be an agreement that strong canvas tops with rubber soles are one good type of shoe. The G.I. shoe with combination rubber and cordage bottom is good too. If a leather sole is used, hob nails should be put in and extra ones carried. The Japanese use canvas sneakers.

B. Knife and Other Items

An important piece of equipment, so necessary as to be considered a part of the clothing, is some kind of knife. A machete, 18 inches long, is listed as standard equipment in Appendix IX (added) of FM 31-20. The bolo and the Dutch klawang are good knives. In rain forest or grass jungle, a machete-type knife is absolutely necessary to cut a path. Make sure you have at least a strong pocket knife, for general use.

Fighters back from the jungle have stressed the need of such obvious items as a cheap watch in waterproof cover, and rubber bands, to keep sleeves and pants legs closed at wrist and ankle. A compass is an important item. An automatic lighter is another; old-fashioned, natural flint is necessary for these, since artificial flints decompose in contact with salt air or water.

C. Individual Weapons

Jungle operations are individual operations. And in a contest of individuals, everybody fights. When small units are the basis of both tactics and strategy, and tactics mean ambush and swift attack, there are no behind-the-line areas, no mere "service" troops. Engineers fight, cooks fight, air force ground crews fight; on Guadalcanal the Marine band swung into action and prevented a surprise breakthrough. The point is that Air Force personnel have to worry about the maintenance not only of their planes, trucks, and tools. They have to worry also about their individual weapons.

Small arms in the tropics require considerable care. Dampness penetrates everywhere. Fungus growths attack whatever is vulnerable, or human. No longer is the old army rule enough, "clean the barrel of your piece after every using". In the jungle, clean, dry, and oil every metal surface every day.

Lecture II:
Personal Care, Aircraft Maintenance, and Electronic Equipment

Part II--AIRCRAFT MAINTENANCE

It is impossible to prescribe for every condition that Air Force men are likely to run into in the tropics. Many varied regions, with varying weather, vegetation, and hygienic problems, besides changing operational and tactical situations, make necessary a broad treatment of the subject of aircraft maintenance. A reasonable approach is to treat the problem at its most difficult--on the line with a combat squadron, where equipment is short, and weather and terrain pretty bad. If a line man can keep planes flying in such a set-up--and such is the set-up likely to exist at the beginning of a new strategic operation, because of the mobility of Air Force action--then he should find a more "normal" situation so much velvet.

This minimum approach is necessary because of the nature of air fighting. No matter how much supply has been improved to the larger tropical bases, and living conditions have developed, the advance combat units will probably continue to work from strips chopped and blown out of the jungle, with few necessities available and no comforts. By the time such fields are developed, the fighting will have gone further and the unit will occupy a new advanced base. If you are at a better equipped station than such as these, so much the better. But it is wise to be prepared for pretty heroic hardships.

I. CLIMATE AND WORKING CONDITIONS

We can do nothing about the climate itself, but we can make preparations for tropical life. Again, it is dangerous to generalize. The picture of hot steaming jungle, with forbidding marsh and malaria, is true, but only in certain places at certain times. Though ordinarily near the equator there is not much change in temperature throughout the year, night or day, there are many specific localities where nights in the dry season are cold. Many parts of the tropics are pleasant during the dry season. But in preparing themselves for the worst, men must be ready for a monotony of climate such as they have never experienced. If they find themselves at a fairly inactive station (less likely for Air Force men than for some other arms), they must have devices and methods to counteract boredom and staleness.

There can be no overstressing the need for personal health precautions, especially in the rainy season, when humidity makes keeping dry and clean a hard job. Working conditions are likely to be conspicuous for their unpleasantness. In revetments in the open, the sun will be beating down directly on a hot fuselage, with the heat reflected from steel matting. The humidity will be consistently high, increasing discomfort and reducing efficiency. Hours will not be regular; much work will have to be done at night, to prepare ships for daylight missions. Men will work with a lingering touch of malaria or dysentery. But the planes will fly, because the men will use their brains and guts.

II. FACILITIES AND EQUIPMENT

In preparing for minimum conditions, forget you ever saw a hangar or permanent structure. Of course many of the longer established fields, such as Henderson on Guadalcanal, are by now comparatively sumptuous institutions. But the most important part of a successful, swiftly moving attack is the advanced air strip, where an improvised thatch shed or mat awning will provide all the shelter there is likely to be. Hoists, jacks, specialized tools may be on hand, but more likely they will have to be improvised. Equipment, tools, repair and maintenance parts will be precious, and once lost almost impossible to replace in time for use. Technical supply will have a tough job keeping up with a moving front, even with the most energetic and efficient efforts.

"Cannibalism" is frowned upon by technical supply officers, but under the stress of combat conditions with a minimum or absence of replacement parts, the process has been developed to a fine art. It is the practice of making two or three flyable planes out of three or four wrecked or grounded planes. The theory is that one ship in the air is worth any number of dead ducks on the ground. Of course cannibalism, if ever justified, should be used only as an extreme last resort, when replacements are impossible. American standardization and interchangeability of parts make cannibalism possible. A ship comes back from a mission with a wing damaged beyond quick repair, and a couple of instruments shot up. The wing is taken from a grounded ship, the instruments from still another, if necessary, and the first ship is ready for flight.

Strict salvage is another necessity where replacements are slow. Long treks have been made into the forest on foot, light planes have been landed in nearby clearings, and boats have been employed for a water approach to cracked-up planes, so that they could be stripped of desperately needed parts.

Spares will be needed in greater abundance than back home, but they will be harder to get. Therefore an estimate should be made far ahead, with an analysis of the kinds of combat conditions, climate, and terrain, and also the availability of spares through cannibalism and salvage, in order to judge a minimum requisition.

Nowhere is the advice truer than at an advanced base: "Save it; it might come in handy." From what some returned pilots have said, even the proverbial piece of string or wire has come into use to patch old crates together to get them into the air. Bolts and screws, distributor points, insulator tips, some tubing--these may make the difference between a grounded and a fighting plane. In the combat area, far from a depot, it is usually an insignificant item that grounds a plane. With small parts that have been saved, and some ingenuity, proper repairs are possible. The first men on the Solomons even used copper coins filed down to various degrees of thickness for shims and breaker points.

III. MAINTENANCE PROBLEMS

Airfields generally consist of a single strip, either in a clearing or a patch cut out of the forest. The base may be anything from plain soil to crushed coral, with a paving of one of several types of perforated

steel mats. Shoulders and aprons will be a problem varying with the season, or from day to day, between mud and dust. Drainage is a serious engineering problem, to keep the strips usable in wet weather.

Maintenance sites must be located on natural hard standings, or else such standings must be constructed. Conditions of mud and dust must be kept in mind. Will there be drainage in case of a sudden downpour? Which way will prevailing winds blow dust? Take advantage of shielding vegetation and other topographical features. Another factor is the nearness of native settlements with their possibilities of disease, and mosquito-bearing water.

Tools, like spares, are priceless possessions. Protect them against corrosion, the prime jungle hazard. Clean and oil them often; cover with grease the tools not much used, and wrap them in burlap. If possible, keep tools in lockers in a dry place, or, best of all, in a "dry closet". Do not lay tools or parts on the ground. They can get lost in mud or dust or vegetation, and it would be especially embarrassing to try to explain how tools got lost on ground over which steel mat was later placed. While in use, tools should be laid down on a strip of canvas or in a suitable receptacle. Metal parts that are salvaged or removed from service should be carefully cleaned, covered with cosmolene or similar grease, wrapped in burlap, and stored in dry lockers or bins.

An inventory and record system will have special need for accuracy because of the requirement of dispersing aircraft for safety; the system will also be made more complicated by this requirement. Assuming that there will be a minimum of parts, the supply man will need to have a rigorous check-up to be able to lay his hands on any available part as soon as it is needed.

Transportation is another problem created by the tactical need for dispersal. To be effective, the dispersal plan must leave ample space between craft. But this would work hardship on pilots and crews, and be impractical for quick alerts, if there were insufficient means to get from living quarters and operations headquarters to the dispersal areas. It is easy to say "get transportation", but the problem has only to be stated to be appreciated. A jeep is worth its weight in gold (which is useless at advanced bases, anyway) and local beasts of burden may suddenly seem to be the noblest of animals.

IV. SHELTER AND THE HEAT

Some kind of shelter from the sun and rain is necessary for maintenance work, but it must be consistent with camouflage requirements. A canvas, thatch, or matting lean-to, or a shelter-half stretched as an awning; an improvised nose-hanger; a maintenance stand--these are easily constructed, and are worth the effort.

Very short experience will teach the danger of touching metal tools or surfaces which have been exposed to the hot sun. Wrap cord or heavy tape around the metal handles of tools. Use mats and pads to protect the

knees from hot surfaces. When working inside a ship, you can put the motor generator to use by rigging up a fan or blower system, to create circulation, increase evaporation, and equalize inside and outside temperatures.

Keep the sun out of cockpits, turrets, and nose sections by throwing canvas or plant matting over them. Interior temperatures may be 10 to 20 degrees cooler with windows, canopies, and hatches open, than with them closed, but there is the danger of dust and moisture entering. If the weather is clear and there are maintenance personnel to watch and clean the plane, then ventilation of pilot, bombardier and navigator compartments is desirable as a means of guarding against heat warping of delicate instruments. Under other conditions, keep them closed.

Structural surface temperatures are dependent on the heating effect of the sun, and the cooling effect of whatever wind and humidity there may be. Skin temperatures will run 1.4 to 1.5 times those of free air temperatures. Interior temperatures will be somewhere between free air and surface skin temperatures. Wing, empennage, and fuselage interiors, however, may rise to 1.4 free air temperature. High temperature is not in itself harmful, but combined with high humidity it is extremely destructive to certain aircraft materials.

V. CORROSION

Corrosion, particularly by salt water, is a major problem. It is a chemical process by which metals exposed to air or water or salt solutions combine with oxygen, as if to return to the natural state of the ore from which they were refined by the removal of oxygen and other substances. The hot, humid climate of the tropics, particularly where the moisture in the air contains salt, induces quick corrosion. Another factor in corrosion is mechanical stress: metal parts which take the most punishment are those which offer least resistance to corrosion. The metal components of landing gear that take a beating on landing strips will corrode faster than the other metal parts. Corrosion is worst under the abnormal stress of violent tropical weather and rough landing strips.

Corrosion is easy to recognize in the spots on the surface of metal. It appears as brown-red rust on iron and steel, white specks on aluminum, whitish powder on magnesium, blue or green on copper, black tarnish on silver, etc. It may penetrate so deep that such mechanical properties as tensile and fatigue strength are seriously impaired. Akin to corrosion is corrosion fatigue, the result of the action of humic acids working along the grain of metals and weakening them.

Different metals show different rates of corrosion. But if two or more dissimilar metals are exposed together, corrosion by electrolytic process, or the reaction between the metals, will proceed faster than the rate at which the more active metal would corrode when exposed by itself. For this reason, whenever making repairs, use the same metal that was originally used; if this is impossible, provide some insulation between the two metals.

Metals are protected by finishes. Protect the finish, and the metal is safe. Finishes are platings, enamels, dopes, varnishes, lacquers, paints. Finishes serve as shields; more stable chemically than the metals they cover, they resist corrosion. The finish can be removed by an erosive influence such as sand abrasion, or other mechanical agency, and also by the action of bacteria, microscopic animals, or fungus. So, keep surfaces clean: wipe off foreign particles and imbedded dirt; avoid scratches, gouges, dents, chipping; touch up all damaged spots and weak places in the finish, so that corrosion cannot start on the base metal. The service life of much equipment depends on how much care is given to the protective coating. Pitting, an especially harmful form of corrosion, is usually started by foreign metal particles, imbedded dirt, or excessive strains that damage surfaces.

VI. DUST

Dust is a hazard to aircraft not only in the desert. Not only in hot dry regions, but also in wet areas during a spell of sun, dust will blow around or wait to be blown up by prop wash.

Induction, fuel, and oil systems must be protected. An engine breathes dusty air a part of the time in some tropical areas, and all of the time in others. This dust, mixed with oil, has terrific abrasive action, especially if it is volcanic ash or coral dust. Some airfields are located on islands composed almost entirely of one of these two substances. The result is rapid wear of pistons, rings, cylinder walls, and valve mechanisms. All this means excessive gas and oil consumption, loss of compression, and plenty of trouble for some pilot in a jam who will need every bit of power he can squeeze. Engines will last only a fraction of their rated life when ground to death by dust. Watch for a sharp rise in oil consumption, as an indication of trouble.

Filters are necessary, especially for ground operations. Air cleaners, oil and gas filters, by their very nature and function clog up and decrease in effectiveness as they are used; therefore they must be checked, cleaned, and inspected on a rigid schedule. Worn out filters and cleaners must be replaced immediately, so keep an ample reserve stock ready. Two types of induction system filters are used. The wet filter consists of a wire mesh, finer and more closely woven where the air leaves the filter. The dust is caught by a film of oil adhering to the filter. The dry filter is made of felt framed by wire screen, bent in accordion shape and mounted obliquely, to present greater surface to the incoming air. The air is slowed down, and the dust lightly strikes the filter surface and falls away. The wet filter requires more care, but is considered more effective.

Covers serve a double purpose in tropical maintenance. They help keep down trouble from tropical rains, and from dust. Engine and cockpit covers should be installed when aircraft is parked. They should be tight-fitting and tailored to the job, else they will be of little use in a tropical downpour. Rain can drown out and shorten the life of electrical equipment and promote corrosion elsewhere. Dust will start trouble mainly in engines. Keep engine covers on the ship at all times when it is not being serviced or prepared for flight. After servicing, replace the covers. This is another habit that should be automatic.

VII. THE PROBLEM OF LUBRICATION

Any flat statement about lubrication in the tropics will run into a contradiction: ordinarily, when humidity is high and corrosion is a threat, liberal and frequent lubrication is required; but when there is plenty of dust around, despite the humidity, the dust will mix with the lubricant and form a murderous abrasive. The decision will have to be based on experience in the specific area in which you are working. Anticipate conditions of wetness and dryness--the first calling for plenty of lubrication, the second requiring a minimum.

VIII. CLEANING AND MAINTENANCE CHECKS

A ship clean of mud and dirt has two advantages: its speed is appreciably increased, and its landing gear is more likely to retract, extend, lock, and unlock properly. In most tropical areas mud is thrown all over an aircraft. Washing and cleaning must be regular chores.

The plane must be kept clean inside as well as outside; a pile-up of dirt may bounce around and hit the pilot's eye at just the wrong moment. Landing gear assemblies must be kept free of corrosive action. Also check control cables for dirt, particularly where they pass through fair leads and pulleys.

Water will condense or gather in dead air spaces in the wings, fuselage, and tail group. Sometimes it gathers in such quantities as to seriously affect the weight distribution, and thus the balance and maneuverability of the plane. The water is also a corrosion hazard. Provide drain holes where they will help, and use scotch tape to seal miscellaneous small openings through which moisture may condense. Sand likewise can collect and disturb balance.

In any routine check, moving parts must be gone over with especial care. Landing gear, bomb door, tail wheel, flap screws and worm gears, anti-friction bearings, plain bushings, gear boxes, control bearings, cowl slides, etc., must be cleaned, inspected for corrosion, and relubricated frequently. The extreme violence of tropical storms may cause leaking tanks, loose rivets, etc. Cloth, fiber, rubber and other materials disintegrate fast in the tropics. Further, they are attacked and damaged by fungus and insect pests. Check fabric surfaces often by tapping lightly with your knuckles. If the dope shows signs of cracking, sand the entire surface lightly with fine sandpaper and apply new dope. If the fabric is too worn to repair, replace it.

Tires, hatch seals, self-sealing fuel tanks, plexi-glass, bungee cords, boots, safety belts, chutes, life rafts, vests, covers, upholstery, navigation and medical kits, all require constant inspection. At the first signs of disintegration, either repair or replace the article. De-icing equipment should be removed for tropical operations. Watch fuel and oil lines; they disintegrate rapidly, blowing out especially around the fittings. Lubrication and hydraulic system packing must receive special care.

Flaps may require reinforcement to prevent damage by flying mud or coral. A slippery steel mat causes excessive wear and strain on main strut links and bolts. Abnormal side loadings are imposed on bracing by the slippage side to side. Where conditions permit, grow grass as a cushion, or cover mats with dirt and coral. A gravel base will improve drainage.

IX. TIRES, ARMAMENT, INSTRUMENTS, ETC.

Tires will be cut down fast by steel mat or dry crushed coral. Water and mud covering the strips are also hard on tires, since sliding on take-off and landing cannot be avoided, and sliding wipes the steel dry; tire temperatures will rise and rubber will burn, leaving a flat spot on the tire. At Milne Bay at one time the average life of front tires was five landings. This is an extreme case, but it does illustrate the problem. Diamond tread tire is best for steel runways. On a coral runway, smooth tires throw up fewer pebbles against elevators and props. Check tire inflation; tire pressures vary 15% for each 60° variation in temperature.

Armament is quickly attacked by tropical corrosion. When a ship lands, cover or seal all guns, and seal the chutes immediately. Be sure to remove seals from chutes and covers before takeoff. Guns may be left sealed for maximum airspeed; the first shot will clear the muzzle. Ammunition must be stripped, cleaned, and oiled frequently. Clean daily all guns, bomb racks, and shackles. Store ammunition in a dry place. Ammunition should not be kept in the plane any period of time, since corrosion may cause disastrous jams. Moisture may affect electric turret operation. Bomb sights and reflector sights are particularly susceptible to fungus growths which will cloud and etch the lenses.

Instrument maintenance is a continuous job. Not only are the instruments affected by condensation, but humid climate will also encourage mildew, mold, and other growths. Clean, dry, air, and oil continually.

Electrical equipment is subject to harm by moisture. Wires and cables will tend to corrode and short-circuit; wire sheathing, plugs and jacks, and ignition harness are especially susceptible to moisture.

Electrical props are affected by condensation and moisture. Pitch-changing mechanisms require constant inspection, especially governors, relays, and solenoids. Prop blades will become pitted, and must be smoothed carefully. Wipe the blades daily with light engine oil, to save the plating.

Generator brushes and distributor fingers must be kept dry. Magnetos should be sealed against moisture. Starters may short out.

Condensation in conduit boxes and elsewhere may be forestalled by drilling drain holes. Generally drains will prevent condensation, but they must be carefully placed to prevent weakening structure or altering characteristics.

Battery terminals and cable connections must be cleaned frequently. Vaseline applied to the terminals will minimize corrosion. Check the specific gravity of battery electrolyte frequently, and do not permit the battery to become overcharged. While there may not be much evaporation, there will be active chemical reactions in the battery.

Carburetors are especially susceptible to internal corrosion. They should be removed, disassembled into major parts without disturbing critical adjustments, inspected, and cleaned.

High humidity causes excessive condensation in fuel tanks. Potassium dichromate is effective in holding back corrosion in fuel tanks.

Prestone expands under extreme heat; drain and flush the coolant system at least every 50 hours.

X. CAMOUFLAGE

Protective measures must be adjusted to the varieties of terrain and vegetational features, ranging from level plains to hills, and open grass lands or savannas to dense rain forest. Dispersal, for example, is more practicable on level ground than in hilly terrain. Danger of enemy infiltration increases with the density of vegetation. It may be necessary to cut openings in the jungle to afford fields of fire for defensive machine guns. Flat tops will be necessary in open savannas, but of course with tree concealment, natural means are sufficient.

It is obvious that camouflage methods must be changed with the seasons. Marked changes in the color of vegetations will occur from wet to dry season. During the late dry season many trees will lose their leaves, and others will turn brown. After the rains start, the many new leaves and buds may cause a predominance of yellow-green coloring, with flower hues thrown in. Tropical grasslands also undergo changes in color. In the latter part of the dry season, much grassland may be burned over. After the rains start, fresh green grass grows quickly.

A first principle of the use of natural materials is that branches, vines, and grass will wilt, and must be replaced often. Further, much tropical foliage has a dark upper side and is lighter underneath; care must be exercised to place the materials in their natural position.

Caves and rice fields have been the scenes of fighting, and offer both advantages and disadvantages to the concealment worker. Air Force men are more likely to find themselves in such sections as rubber plantations, where landing strips can be set down among trees.

The Japanese had an advantage over our soldiers at first through the use of sound effects in fighting. They could reproduce natural sounds, and time their attacks or fire so as to coincide with blanketing sounds. The use of sound both to deceive and to detect the enemy comes under the definition of camouflage.

Snipers' suits and other camouflage devices are useful, but may be offset by movement. Animals which are adapted to their environment "freeze" when they hear a strange noise, or suspect danger. In the present fighting, many a man has lost a single-combat duel because he moved first, betraying his position. When you have to move, proceed along a line of stationary objects, rather than across the line: move along a fallen tree, not over it. All the color blending in the world cannot conceal silhouettes moving. Further, camouflage suits must be adjusted to fit the season and background.

Lecture II:
Personal Care, Aircraft Maintenance, and Electronic Equipment

PART III--MAINTENANCE OF ELECTRONIC EQUIPMENT IN THE TROPICS

Aircraft have a serious problem, besides those just described, a problem shared by the Signal Corps and all other units using electronic equipment. This problem is the combating of the effects of moisture on radio and other electronic instruments, a problem especially pronounced in aircraft because of sudden changes of temperature and pressure in ascent and descent, and long exposure to high humidity conditions. Special materials must be used and special processing performed on the component parts of the electronic equipment.

I. EFFECTS OF MOISTURE, AND COUNTERMEASURES

The jungle and tropical weather have certain common effects on radio operation. The range of radio transmitters on the ground is greatly reduced by thick forest, and sets are of almost no use at night, probably because the high humidity acts as a kind of "ground". Transmitters reliable for fifty miles in fairly open country may not be satisfactory for even five miles in thick rain forest. If antennae are lifted higher than surrounding trees, however, range is extended.

The greatest danger to efficient radio and electronic operation, and to normal life of parts and instruments, is moisture. This affects various parts in various ways; it causes leakage in condensers, jacks, and plugs, corrosion and short-circuiting of wires and cables. In detail, the breakdowns of electronic equipment include: open circuits in transformer windings, chokes, relays, wire-wound resistors, and molded resistors; the development of leakage in mica condensers molded in bakelite, paper condensers of the tubular type, bakelite terminal blocks, switches, jacks, and plugs; the breakdown of insulation between individual windings and between the windings and cases of transformers; leakage due to fungus growth in critical parts of the circuit; the multiplying of bacteria; the attacks of insects; the warping and disintegration of insulating material; and the collapse of woodwork.

Several methods, devices, and materials have been used to thwart the effects of humidity. It is apparent that the very heat of a piece of radio equipment in operation will help keep it dry. The heat that is developed by resistance and the dissipation of electric power keeps the apparatus warmer than the surrounding air, or "ambient", as it is called, and above the dew point, that temperature at which moisture condenses from the air on a surface. For this reason, some authorities suggest that receiving sets be kept turned on continuously, so that a current is always running, and keeping the temperature up. In some sets such as transmitters, continuous operation is not feasible, and heat must be applied from outside. This is usually accomplished by keeping an ordinary light bulb lit near the set, maintaining a sufficiently high temperature to keep moisture from condensing.

Another method of keeping working parts dry, even when not in use, is the application of water-proof or water-repellent coatings. Several of these have been used. The most common type is wax or pitch, applied in liquid form at fairly high temperatures, and then permitted to cool and solidify. A drawback is that wax will run at high operating temperatures. Other compounds, less widely used until recently, are special chemical preparations like Dogardite and varnishes such as Glyptol. Vapors of methyl chlorsilane substances have been used as coatings, but may form corrosive acids. An auxiliary drying method employs packets of a dehydrating agent, such as calcium chloride or silica gels, placed close to the apparatus. These absorb water, but must be replaced and renewed.

Somewhat the same problem applies to wires and cables. Some types of insulation, such as certain compounds of rubber, or cellulose products, are likely to deteriorate under constant humidity, finally allowing penetration of water and short-circuiting. Either special material must be used for the insulation, or standard wiring must be specially protected.

Other sources of trouble are fungus growths, which attack glass and plastic instruments and lenses; bacteria, which are likely to grow anywhere; and insects, the very presence of which, dead or alive, can cause disintegration of material, short-circuiting, and leakage. Special preparations, such as camphor gum, and precautions in cleansing will prevent the growth of fungus and mold. Shields can be devised that will prevent the entrance of insects.

II. MATERIALS AND METHODS

The same principle applies in the care of electronic equipment that is so important in the care of small arms: daily care, especially cleaning and drying. Recently, with increasing awareness of the need for specially prepared equipment, and moisture-proofing at the point of manufacture, the troubles of the radio operator and maintenance worker in the field have been lightened. It is still essential, however, that every one who will have contact with radio, and who will depend on it for safety and the success of a mission, understand the problems and solutions connected with tropical operation. Men in the field may be supplied with moisture proofing kits to protect their equipment; or they may find it necessary to improvise their own forms of protection with materials on hand, to prevent breakdown and quick deterioration of equipment. With limited supplies at an advanced base, the need for insuring longest life for every part is obvious.

Another reason for understanding how tropical conditions affect equipment is that such knowledge will give an inkling of where to look in case of failure. The operator will know beforehand where to expect trouble because of insufficiently protected coils, resistances, or wiring, and also what replacements he should have on hand.

A. Drying and Keeping Dry

A first step in preserving equipment, or preparing it for moisture-proofing treatment, is to dry it thoroughly. Equipment without any special treatment will have a reasonable life of service, if it is kept at a temperature higher than its surroundings. Equipment that is to be moisture-proofed according to Signal Corps recommendations must be baked or dried at fairly high temperatures for several hours, but this process is less likely to be done in the field than in the factory.

1. Raised Temperatures

If no material for protective treatment is available, the operator will have to maintain moisture-repellent temperatures. Usually the heat of normal operation is sufficient to keep the apparatus above the dew-point. For this reason many units employing electronic equipment in tropical areas have partly solved the problem by keeping the filaments on continuously; or else they have rigged up a bulb which burns always inside the set. This bulb might be hooked up to the gasoline-motor-driven battery charger. Many tropical installations, and even homes, have the institution of the dry-closet, near the bottom of which a lamp or heater is kept going continuously; electronic equipment, certain packaged foods, leather, and metal material are deposited there overnight, or when not in use. Even if the set is sufficiently protected without a dry-closet, spare equipment and parts should be kept there.

2. Dehydration

Chemical dehydrators are useful in shipment or storage of equipment, and can help keep apparatus dry, but should not be used alone. According to a Signal Corps investigator, there is some danger in the use of these materials, such as calcium chloride and silica gel, since they give off a fine dust which attaches itself to circuit elements and encourages bacteria growth. If they must be used, the absorbing agents should be placed in a bag within a bag. The main drawback is that unless the part to be dried is itself closed off from the air, the drying property of the dehydrator is soon exhausted.

3. Night Condensation

Special care must be taken to keep the apparatus dry at night. Temperature falls rapidly after sundown in some tropical areas, and water condenses immediately out of the air. Some operators have attempted to solve this problem by making the set container airtight, and shutting it up while it is still warm. The danger here is that while the air in the set may have been dryer than the air outside while it was in operation, at night, when the air within the container cools rapidly, there may still be some moisture imprisoned, which precipitates as the surfaces "breathe".

B. Wax and Pitch

After moisture is once driven out by heating, it can be kept out more or less permanently by a water-tight coating. One such type of coating includes special waxes, greases, and pitch preparations. There are many such products on the commercial market, but of course the individual radio operator or maintenance man will have no choice in the field of operations. It is advisable, however, that he follow carefully the directions for application of the compounds that may be supplied him, with special reference to the temperature of pre-heating, and the drying time prescribed.

1. Transformers have been found to break down because of breaks in the windings, the result of electrolytic corrosion. Cracks in impregnating waxes permit moist air to enter the windings, causing corrosion. One source of information on experience with audio-transformers in tropical areas

points out the frequent failures traced to the use of Scotch tape in the construction of the coils. "Invariably where this tape is used, failure results from electrolytic action on the copper wire. It seems to matter little whether the coil is well impregnated with varnish or not. Even when the coil has been well impregnated and then sealed in pitch or wax, failures have occurred ..." Gummed paper tape is also found dangerous, and any handling of the wire with bare hands is to be avoided, because of the corrosive effects of perspiration. Other authorities repeat the caution against using paper as insulation in transformers. There is some disagreement whether both a basis of wax and a covering of varnish should be used, or simply a good varnish.

More than one observer points out that trouble frequently results from coil windings which are at a positive potential with respect to their metallic case or core. This condition, with the aid of moisture, causes electrolytic action to take place, resulting eventually in open circuits.

2. Coils suffer from the use of cellulose products such as paper, cotton, wood cellophane, etc. Careful covering of the coil surface is important. Sometimes frequency drift may be encountered because of the impregnation wax "flowing" under extremes of temperature. A precaution that should be taken is that R.F. and I.F. coils be closed so that insects cannot enter. An insect may take a fancy to the wax in which the coils have been dipped; it dies, and after a while, its body causes corrosion of the coil wire.

3. Condensers for high impedance circuits, it is generally agreed, should be of the mica type, if possible, and made impervious to moisture by means of a wax or varnish coating. Paper tubular condensers, unless given special treatment, are likely to develop leakage and cause trouble. Paper condensers in hermetically sealed tins are satisfactory for use in high impedance circuits. For paper tubular condensers in these circuits, a simple precaution is to place the tubular condenser inside a wax-impregnated tube of larger diameter and seal off the ends with a soft, high-melting-point potting compound. The aluminum can appears to be the most satisfactory container for electrolytic condensers.

4. Resistors should have ceramic or glass tube insulators. The ceramic materials should be treated with an impregnating substance to prevent the absorption of moisture. If wire-wound resistors are used, they should be properly protected from moisture, and the potential removed when the equipment is not in use.

C. Varnish

A special list of requirements for varnish impregnation of coils (transformer, choke, and other) has been set up by the Camp Evans Signal Laboratory. Specification No. CESL-44 calls for a synthetic resinous phenol aldehyde. This material is superior to waxes ordinarily used, because it can withstand a higher operational temperature without flowing--as high as 250 degrees F. Every precaution is taken in the varnishing process to prevent air bubbles and other flaws.

The Signal Corps recommends the use of varnish as moisture-proofing whenever possible, in preference to wax and pitch materials. It is clear that the best precautions are those taken at the point of manufacture, with

every component carefully chosen and treated with tropical use in mind. However, for those sets not so manufactured, the Signal Corps has worked out specifications for material, a kit with the necessary spraying equipment and moisture-proofing agent, and an approved method of field application. No one material is exclusively recommended, although Moisture-Proofing Kit No. 68-Q-4 is built around Glyptol, a varnish product of General Electric, which has been widely successful. A redesign of the kit, built around infra-red drying lamps instead of an electric blower, uses the same varnish.

In general, the procedure for proofing with varnish is as follows:

a. The equipment is first cleansed of all foreign matter--dust, grease, fungi, insects.

b. The equipment is dried, by portable oven, field-kitchen, electric blower lamp, or infra-red lamp, to a temperature not exceeding the melting point of the impregnating waxes incorporated in the set. The time of the drying process depends on the degree of moisture in the components, and the need to get the set back into operation.

c. Immediately after the drying, all conducting parts, such as sockets, relay contacts, variable condensers, and moving parts, are covered with masking tape.

d. All circuit elements and wiring are sprayed thoroughly with marine lacquer or varnish containing a fungicide. As the temperature drops, the varnish will be drawn into the insulation on wires, coils, etc. Therefore, two or three coats must be applied, and all condenser and resistor ends touched up. Where resistors or condensers are replaced in the field, the new elements will be treated with a brush.

One suggestion has been made that Fourth or Fifth Echelon depots be equipped with sufficient moisture-proofing equipment to treat all sets in stock. These sets would be sent to replace sets in the field, and the turned-in sets would then be moisture-proofed.

D. Dogardite

Another preparation that has met the approval of Signal Corps investigators is Dogardite. Since the application requires considerable apparatus and technique, the process is primarily intended for the point of manufacture, or for large depots. It is applicable to rigid insulating materials having high porosity. Dogardite is an "extremely light impregnating liquid, and it acts by low viscosity penetration during which highly water-repellent solids are deposited in the pores and capillaries of a structures. The deposited solids tend to bulk, on drying, out of all proportion to their weight."

The insulating material to be treated is first baked for a period of two or three hours at 200 to 215 degrees F., in order to drive out moisture. Then in order to cool without absorption of moisture, the piece is transferred immediately to a calcium chloride chamber. The Dogardite solution is kept in an air-tight, clean container, with several inches of air space above the level of the fluid. The piece to be treated is placed in the solution, and then a vacuum drawn above the solution. This helps draw air

out of the pores of the insulation. When the piece stops bubbling, in probably a half hour at most, the vacuum is released. The piece is left in the solution about five minutes so that atmospheric pressure will force the solution into the pores. It is then hung up to dry.

It is advisable to use different tanks, one for bakelite and other phenolic pieces, another for ceramic pieces. Some of the varnish used in making bakelite is dissolved by the solvent of the Dogardite.

Ordinary Dogardite has no fungus-resisting qualities, but a special variety, Dogardite "F", kills fungus molds.

E. Other Elements

1. Wiring and Cable. One opinion that is universally shared among those with experience in the tropics is that hook-up wire having low-grade rubber insulation should not be used. Synthetic rubber, such as neoprene, has met with approval. General Electric Flamenol insulation has also been widely approved.

The outer jacket and insulation on cables should be made of 60-per cent rubber or of neoprene. Cables employing an inner sheathing or reinforcing core of hemp or cotton are to be avoided; the cellulose material exposed at the openings in the cable serves as a wick, allowing moisture to permeate the entire length of the cable, resulting in deterioration of the insulation.

2. Plugs and Connectors. Semi-enclosed electrical connections such as plugs and jacks are subject to resistance breakdown within a few days unless they are taken apart and cleaned daily. Some dissatisfaction has been expressed against plugs that are cadmium-plated, because of oxidation, especially in salt sea air. Stainless steel contacts have gained general approval.

3. Batteries. Constant care is necessary to keep batteries from losing a good part of their life expectancy. Especially in the tropics, where corrosion and oxidation are so quick to set in, contacts and terminal posts must be kept clean. "B" batteries will give better service if both the inner and outer cases are well impregnated with wax. This applies to light-and heavy-duty types of "B" batteries as well as small "C" batteries. "A" batteries function best when the specific gravity of the liquid is maintained at the recommended level of 1275 to 1300.

Some "B" batteries have been found to fail prematurely because of corrosion of internal connecting leads, without damage to cells. Use of paper or cloth insulators between cells and batteries is to be avoided. A common practice is to wrap "B" batteries in wax paper before shipment.

F. Insect and Fungus Proofing

The damage that insects and mildew can accomplish in a short time has been mentioned in the above discussion of various parts to be protected. Constant cleaning is the most obvious counter-action to both sources of trouble, but there are further measures. Ants can be kept away from sets

at ground bases by providing an oil barrier between equipment and earth; the table legs can be placed in oil cups. Flying insects must be watched for and cleaned off.

Moisture, with attendant fungus and mildew, can be kept off by heat, but a further precaution in the form of camphor gum, which gives off penetrating vapors, is necessary to stop fungus. Varnish, of course, keeps fungus from doing damage to most parts, but it cannot be used on glass lenses, which are etched by mold. The same applies to glass inspection windows, and photographic negatives. Camphor gum will prevent the beginning of fungus mold, and will stop its spread, but cannot be depended on to remove growth already started. The special Dogardite variety, "F", must be used to prevent fungus growth, where that preparation is used for moisture-proofing.

G. Soldering Precautions

An important caution in the care and maintenance of electrical equipment is the scrupulous avoidance of the use of acid core solder and other corrosive fluxes in making repairs and replacements. Only resin core solder should be used in making wiring repairs and replacements.

GENERAL SUMMARY

Certain broad principles become clear in the maintenance of electronic equipment in humid regions, whether in airplanes or on the ground:

1. Ordinary equipment, perfectly serviceable in the United States, will fail in a short time in the wet tropics.

2. It is recognized that the best way to handle this problem is to have special treatment for sets intended for tropical operation. This treatment is best accomplished at the point of origin--that is, with the original manufacturer. Specifications for such manufacture are being set forth by the Signal Corps.

3. For sets sent to operations areas without special treatment, treatment must be arranged, either at supply bases, or at point of use.

4. Treatment involves application of a water-tight coating on radio components. This is likely to be a heat-resistant varnish, or a wax or grease. It is important that operators and maintenance men know all kinds of proofing.

5. In applying water-proofing, whether wax, varnish, or special chemical preparation, care must be taken in preliminary preparation by baking the components, to drive out all moisture; and in subsequent drying of the treated components, to prevent air-bubbles and open spots. Instructions for the use of various compounds must be followed.

6. A uniform principle appears in operation of parts like batteries, wires, and plugs, that cannot be treated in the ordinary way: keep parts clean, make sure they are not deteriorating from moisture, and replace if undependable. Heat during storage is a good preventative.

7. As with all equipment in the tropics, the key-word is constant care and cleaning.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

T-III THE TROPICS (THREE LECTURES)

LECTURE III—SURVIVAL

Prepared By

THE ARCTIC, DESERT AND TROPIC INFORMATION CENTER

OFFICE OF ASSISTANT CHIEF OF AIR STAFF, INTELLIGENCE

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ARCTIC, DESERT AND TROPIC INFORMATION CENTER
ARMY AIR FORCES
* * *
School Lectures

THE TROPICS

Lecture III:
Survival

I. PRELIMINARY PREPARATION

"How to come through alive after a crash-landing" is a subject which requires little specialized information and training, if there has been considerable thought and good basic training beforehand. Most of the job of self-preservation should be done before the take-off, before the plane starts on its last mission.

A. Attitudes

You can start preparing right now for the solitary hike you may take through the jungle months from now--in fact, you started your training for survival when you began receiving this information on living in the tropics. It is largely a matter of psychological preparation: knowledge about the areas will give you confidence, and confidence and control will make it easier for you to put to good use what you have learned. If you have mastered the facts about simple existence in the tropics, you are prepared to take care of an emergency. The basic facts remain the same, whether in camp or on your own: What hours to work or travel; when to rest; when to eat; how to cook food; what foods to cook; what clothing to wear, and when; how to recognize local plants, and local animals.

Start learning this material at first hand as soon as you hit your tropical station: Where is the water supply, and what must be done to make it safe; what native foods are used in the mess, and how are they prepared; what wild foods are good to eat; who are the tribes in the neighborhood; what languages do they speak; what are certain key words; what are the religious customs and superstitions you must not insult; what are some general religious ideas and tabcos that are likely to exist wherever you will have to call on natives for assistance; how do the natives tell direction; how much do they understand of the present conflict; what are their attitudes toward Americans, toward Japanese?

A word of caution about all this information you will gather. Hold it flexibly. Each time you change stations, and move closer to Japan, do all this over again. Realize that not all natives are

alike; not all jungle-land is alike; languages and customs and mediums of exchange may differ greatly from valley to valley; animals or snakes may exist on one island but not on another. The important thing is to develop an attitude of willingness to learn and to adjust oneself to wherever one turns up, or falls into.

B. Equipment

Start thinking about equipment now, while you are still where you can buy things. A standard list of jungle clothing and equipment is presented in Appendix IX (added) of FM 31-20. In addition, a variety of emergency kits for Army Air Force personnel is available. But each member of a crew might desire to make his personal variations and combinations from the material available. Make sure now of certain important items: (1) a rugged watch; (2) a dependable compass; (3) a large knife; and (4) a sheath which can be strapped to the body, not merely to the web belt; (5) rubber bands to help keep sleeves and trouser legs closed; (6) a cigarette lighter; (7) handkerchiefs; (8) waterproof matchbox; (9) a waterproof, plastic pouch for cigarette lighter, compass, and watch.

1. Check It Yourself

When you have these things and the G. I. kits, you may desire to arrange the contents to suit your own tastes, and your knowledge of the country you will be flying over. But make one resolve right now: inspect your emergency kit before every take-off, to make sure it is in shape and all there. The old fraternity-house habit of borrowing clothes without permission might extend to articles in these kits. Do not trust anybody. Check your emergency kits yourself.

2. Contents of Kits

The standard jungle clothing and equipment list contains the following items intended primarily for ground forces:

elastic camouflage liner for helmet liner M_1
jungle boots (rubber sole, high uppers)
cushion sole socks
jungle uniform (zipper, insectproof)
18-inch individual machete
sheath for machete
jungle pack (waterproof rucksack)
waterproof clothing bag
jungle hammock
matchbox, waterproof, with compass
flotation bladder

Some of these items are repeated, or approximated, by other items in A.A.F. kits. For example, the Basic Parachute Emergency Kit, Type B-4, consists of a seat-pad kit, about 15" by 13", with a felt inset with cutouts for holding components, and encased in a zipper-fastened canvas cover. A one-inch-thick pad serves as a cushion. The carrier may be used as a knapsack after landing. Contents:

signal flares	fishing kit	cooking pan
machete	can of solid fuel	compass
signal panel	first-aid kit	gloves
match case with matches	mosquito headnet	goggles

special parachute kit ration unit made up of Field Ration "K" components

Personal kits, to be carried on the body, rather than in the parachute harness, are available. The "Emergency Sustenance Kit (Escape), Type E-3" is designed to be carried in the pocket. It is packed in a cloth bag, 12" by 6", which can be used as a water container. It contains:

matches	halazone tablets	dextrose tablets
compass	benzedrine tablets	bouillon powder
hacksaw blade	field ration "D"	chewing gum

There are also two "Emergency Sustenance Kits". One, an "individual bail-out ration, Type E-6", contains two units of Field Ration "K" and can be snapped on the chute harness before bailing out. The other, "individual bail-out water, Type E-7", provides two cans of drinking water, pasteurized, which can be snapped on the chute harness.

Another kit, intended for carrying in airplanes, is the "Emergency Sustenance Kit (Desert and Tropic Implements, Type E-8)". It is intended for desert and jungle use, and contains a combination of .22 cal. and .410 gage gun; ammunition; generator flashlight; machete and sheath; flares; paulin; mirror; first-aid kit; sewing kit; soap; and sunburn ointment.

There are other types of kits available--for individual carrying, for airplane stowing, for dropping to personnel from rescuing airplanes. But you get the idea. Make sure there are supplies, kits, personal equipment, etc., which will be suitable for use in territory you may be forced down on. Get your supply officer to look them up and try to procure them. Consider where your mission will lead you, whether over jungle, or water, or desert islands, and vary your equipment accordingly. You may find it wise to change the kit you have along for each mission. Or better, hit on a compromise that is likely to suit the broadest variety of contingencies, and then make sure you have the items before every trip.

C. Native Attitudes: Know What to Expect

There are other factors to be considered before the takeoff. Because of the importance of natives in helping airmen get out of trouble, you must give thought to them before beginning any operations. There is a limit to how specifically we can prepare for any mission, since we cannot be sure in which area we may have to call upon natives for aid, and the characteristics and attitudes of the native population vary from place to place. But what we can do is

have an idea whether the inhabitants of the area the flight will cover are friendly, or shy, or hostile. We shall thus know whether there is some immediate reason why we should avoid them as we would the enemy. From our sources of information in the United States we can get a general notion of how natives will react in any area, but we must remember that war is a flowing and changing thing and natives shift their allegiance; therefore, you must depend on the S-2 in your group or squadron who can supplement general intelligence reports with specific knowledge more recently acquired. The Japanese, with threats and promises of reward, may have turned inhabitants formerly our friends, to our enemies. Or the thoughtless actions of our own men may have antagonized a formerly friendly tribe. In this connection you do a service for other airmen, who will follow you, if you act well with natives.

D. What to Wear on Mission

Another consideration before the takeoff; what clothes will we wear? The usual advice is "Wear the shoes you'll have to walk home in", and lace them tight so they will stay on when your parachute opens. Several pilots declare that loose or low shoes kept going down fast when the pilot was pulled up short by the parachute. It is true that some fighter pilots over Java and Australia preferred to remain practically naked when flying, on the theory that spouting gasoline from a punctured tank is absorbed by clothing and shed by skin. But the recorded number of flash burns on bare skin argues for covering the body. For high altitude flights, of course, there is no choice--heavy clothing is necessary. The problem is how to keep from roasting in high-altitude clothing, before the plane takes off. In large bombers, some crews put on their clothing after the plane reaches a cool height. But this is harder for smaller planes. Wool clothing, by absorbing body moisture, does away with some of the danger of a sweat-drenched body suffering from chill when the body suddenly cools at high altitude.

It is a good idea to start developing resistance to the sun right now. Even though you are not going to go around in nudist fashion at midday, the more tanned the skin, the less quickly you will be sunburned if you have to be exposed in open clearings. And you cannot start getting your tan gradually after you find yourself downed in the rain forest where there may be too little sun, or on a life raft in the ocean where there certainly will be too much sun.

II. CRASH-LAND OR BAIL-OUT?

The decision whether to attempt to save the plane and its equipment by landing it in an emergency, or to abandon the ship and take to parachutes, must of course be made on the basis of facts different for each situation. The commander must think fast, and once the order is given to bail-out, the men must jump fast. But not so fast as to forget the equipment which should have been carefully prepared and put handy for just such an order.

A. Difficulty of Salvage

Specific methods of crash-landing or bailing out will be handled better by other authorities, but some comment would not be out of order here. Salvage is difficult for most planes forced down in combat: the plane might land in enemy territory, in dense tropical rain-forest, on the water. Crash-landing seems advisable only when it can be accomplished on a broad open space, such as a beach or large clearing, within easy traveling distance of a friendly base, or when there are wounded personnel who cannot be expected to take to a parachute.

B. In Case of Bail-out

If bailing out is required, take time if at all possible to attach to the chute the equipment which you may need. Some kits are of course built into the chute; but if these are not available, make sure the stuff is right at hand. Be careful how much equipment you try to strap around your waist, or to your web belt. Several pilots report that their Army .45's snapped off their belt at the jolt of the chute opening. One suggests that a smaller pistol jammed into the top of an army boot is more likely to stay with you, without causing injury. Shoulder and back holster arrangements are advisable.

A general rule in case of crash-landing or bail-out is to stay with, or find the plane, if at all possible. It may furnish shelter, materials for living, and, if in friendly territory, it can more easily attract help than an individual could. Of course, it may be wise to leave the plane. You may be in enemy territory, and your landing might have been observed. Or the plane might have hit in deep jungle where it cannot be seen, and where signal flares and smoke are swallowed by tall trees. Or there may be no food available, and you may have to strike out across country.

III. CROSS COUNTRY HIKES

If no help seems probable in friendly territory, try to fix the location of the plane with relation to local landmarks, decide the direction you should follow, and get ready. One alert flyer on landing took a bearing with his compass on the direction of a native village he had seen while parachuting down. Getting ready involves making sure you have what you need, and then getting a good night's sleep, if possible. You do not think straight when you are tired. Above all, do not start traveling immediately on hitting the ground. Sit and think; take it easy, work out your probable location, and then sit some more and try to remember everything you ever learned about the tropics--vegetation, people, weather, animals. Then pin it down to the area you are now located in. Take an inventory of equipment on hand. Consider the question: is it better to remain here and await rescue, or to try to walk out? Get used to the situation in which you find yourself. Then, if possible, go to sleep. Never start traveling if you land in the afternoon, unless you are sure the

enemy is after you. Remember, it will be pretty hard for him to find you, and by traveling too soon you may take the road right toward him.

If the plane lands in enemy territory, and capture is to be feared, you must be sure before leaving the plane to destroy or hide the instruments and everything else that might be useful. Do not start a large fire that might start a jungle fire, if there is dry brush and wood around.

A. Which Way to Go?

The answer will depend, of course, on where you are. Are you on a small island; on a large mainland; near the enemy; near your own base; lost? All other factors being equal, it makes sense to try to get to the coast. You are more likely there to run into natives or other settlers; there you will find more food. Coconut palms are more likely to be found along streams or near the coast, and fish and shellfish alone would be sufficient to support life. In many jungle areas it is hard to find any edible plants growing wild. Cultivated areas are likely to be along the coast area, and near streams.

1. Toward the Coast

How to get to the coast? Go downhill. A good guide will be the watershed. Find a small stream, follow it till it meets a larger stream, and keep it up until you get there. There are complications, of course: the banks of the streams may be marshy and swampy, or badly overhung with jungle growth. Vegetation grows most richly in watered lowlands. So do mosquitoes. So simply following the bank of a stream may turn out to be a strenuous and complicated business. You may have to cut across higher ground in the general direction of the current.

2. River Travel

One way to travel is by raft. Tie stems or saplings together either with rope or with vines (note: not all wood floats equally well; some wood is very heavy; and all wood, especially palm, loses some buoyancy as it absorbs water. A double layer of logs may be necessary to make the raft ride high). There are dangers to raft travel. Most important is the need to listen for rapids ahead. Get to shore as soon as you hear the sound of water on rocks. Keep near shore, or walk on shore pulling the raft with a rope. Do not travel at night. Malaria mosquitoes breed in pools at the edge of the river. Get to shore, and find a camping spot about half a mile from the river, if possible, in an open clearing, with the wind toward the water. This is a large order, of course, but it is good to understand what the principles are. Keep your rubber emergency raft, if you can.

3. Crocodiles

A question comes up here: Aren't there flocks and herds of man-eating crocodiles in jungle waters? The answer is, Very few,

if any. A greatly overstressed peril of the jungle is the crocodile. His mouth is not built for mastication. What he eats he swallows whole. "But I don't want to be swallowed in any manner!" The answer is that a croc generally will not try to eat what he cannot manage at one sitting, and there are really very few fifteen- or twenty-foot beasts large enough to manage a man. Besides, they have become used to their regular food, and are not likely to experiment with new and strange fare. They will not bother you unless you are right in among them. This is not to deny that crocodiles can be dangerous: they do bite, their tails are powerful, and can move fast. But crocs are not ordinarily man-killers. In a whole year there was only one definite instance of a person's being killed by a crocodile in Central America, where crocodiles abound. In Sumatra, however, there are authentic reports of crocodiles attacking men. Play it safe, but when you see one on the other side of the river, do not get panicky.

B. Animals and Snakes

What are some other dangers of jungle travel? Do not worry about animals. You probably will not see a single one in weeks in the jungle. There are no tigers east of Malaya or Sumatra, where men have been picked off by tigers. Some areas do not have any beasts larger than pigs. Animals are more afraid of you than you should be of them. Snakes? Many south sea islands just do not have any; no dangerous snakes are known to exist in the following groups: Carolines, Ellice, Gilbert, Hawaii, Ladrones, Loyalty, Marshalls, New Caledonia, New Hebrides, New Zealand, Friendly, and Samoan. Sea snakes, all of them venomous, may occur along the shores of these islands, but are not dangerous unless handled. In those areas where there are dangerous snakes, you are not likely to see any. And the chance of stepping near enough to a poisonous snake to irritate it is very slight. But just in case: venomous snakes all inject venom through tubular fangs, which can be recognized. Do not travel at night where there are snakes. If you must, and are not in combat territory, use a flashlight. Snakes move at night.

On ordinary, prepared trips through the jungle areas, it is wise to wear boots, high shoes or canvas leggings, with the trouser legs tucked in to offer greater protection against snake bites, and insects and leeches. But on an emergency trip, this may not be feasible. If you are bitten, you may have to take forceful measures. If possible, kill the snake, so you can get a good look at it. If you are near camp, try to take the snake along, for the medical officer to see so that he can decide on the proper treatment. If you are alone, the treatment requires courage. If the bite is on the arm or leg, apply a tight bandage, not as tight as a tourniquet, above the wound. Make crisscross incisions at each fang mark, one-half inch long and one-half inch deep. Induce bleeding. It is important to apply suction, but sucking the wound with the mouth is dangerous, because the venom might enter small sores or scratches in the mouth cavity. If possible have a flat, thin piece of rubber

between the mouth and the wound. A small heated bottle can be applied to the bite; as the bottle cools the air inside it contracts and creates suction. If the swelling spreads, make new cuts at the advancing edge. Cauterizing serves no good purpose. A standard snake-bite kit is available.

Important warnings: the idea in treatment is not to hasten circulation, which gets the poison to the heart sooner. So try to remain still; try not to get your heart palpitating with excitement. Do not drink alcohol. If you must move, move slowly.

C. Reminder on Mosquitoes and Water

You have already heard a full discussion of the greatest dangers of the tropics: mosquitoes and bad water. Let us repeat: methods of dealing with these dangers should have been mastered before you leave your base. Caring for yourself when alone should be merely a continuense of procedures already a habit through practice. The combination of mosquito netting and quinine or atabrine tablets will lessen the danger of malaria and other mosquito-borne diseases. Anopheles mosquitoes attack mainly at dusk and at dawn. They are most abundant in lowlands. That is why it is wise to seek high ground for a night camp, and to pitch the camp while it is still daylight. Night comes on fast in the tropics. If you do not have netting along, the parachute can be cut into a good body shelter. Sometimes the best (and only) protection against mosquitoes, if no nets are available, is to keep moving, especially if you can travel along a beach or open region where the wind is blowing,

The simplest rule for the fight against micro-organisms is--boil all water. Running water, we must repeat, is not pure water; it might be running direct from a native village, with a dangerous content of sewage and human waste. Clear water is not pure water--deadly germs may be too small to show; whereas some colored water may be safe to drink. The safe time for boiling water, it is generally agreed, is at least five minutes, as stated in FM 31-20. If for any reason boiling the water is undesirable or impractical, then you must use your halazone tablets, ordinarily one to a quart of water. Filtering may help remove small parasite eggs and larvae which might be able to resist the chlorination process caused by the tablets. For this a doubled handkerchief can be used.

D. Sun, Heat, and Body Temperatures

1. Sunburn

Other dangers you must consider are sunstroke and sunburn. The British in the tropics used to believe that the head must always be covered by a sun-helmet, with a cloth extension for the back of the neck, and maybe a spine pad. These precautions are advisable for burning desert conditions, but not necessary in wet tropical areas. Many white residents try to go about hatless for as long as possible,

although in bright light this is dangerous because of heat stroke, and eye damage leading to night blindness. A moderate amount of sunlight is healthful, and should be sought. There is a "too much" degree for everyone, of course, no matter how well acclimated. Try to get as much tan as your skin can take, in preparation for the time when you may have to suffer exposure. Sun-tan oil, which can be squeezed from mature coconuts, would be good to have around, but proper clothing, serving as both insect and sunlight repellent, is the best protection. If without proper covering, remember the experience of the flyer who was being burned cruelly on an open beach, there being no protection. Natives came along, dug a hole, put him in it, and covered him with brush. He realized that he should have thought of this expedient himself.

2. Heat Exhaustion

Heat exhaustion is not directly due to the hot sun, but to the loss of salt from the body. Sweat is salty, and the more you sweat, the more salt your body loses. After a certain point you feel dizzy, weary, sick. Continuing the struggle is not a matter of will power. It is a matter of simple physiology. Even if salt tablets in your water make you feel somewhat sick, take them anyhow; they can be crumbled and dissolved in water. You will feel better quickly. Here is a clear statement on salt, from a colonel of infantry on Guadalcanal:

> It is hot here, as you can see. Men struggle; they get heat exhaustion. They come out vomiting and throwing away equipment. . . The men have been taught to take salt tablets, but the leaders don't see to this. Result, heat exhaustion. . . C.O. Company L reports he had only 35 men; that the rest had heat exhaustion. He did not have sense enough to rest his men, make them take salt, etc.

You will have to be your own C.O. and make yourself be careful. The salt tablet is a simple remedy for a difficult condition. You need the equivalent of a tablet for each hour of heavy work.

3. Change of Temperature

A serious health hazard to white visitors to the tropics is change of temperature. It seems that the body heat-regulating mechanism becomes less efficient in the tropics, and rapid chilling brings susceptibility to colds, pneumonia, and other respiratory diseases, as well as diarrhoea and other intestinal trouble. Avoid sitting in a current of strong cool wind following exertion.

IV. JUNGLE HOUSEKEEPING

Let us turn away from the listing of hazards and deal with finding and preparing food and water, and avoiding what we should not have.

A. Fire and Water

1. Making Fire

Your jungle kit should provide you with water container and cooking pan. You will probably have along a knife and matches or automatic lighter. Nothing can take the place of a knife, although poor substitutes can be found in a sliver of seasoned bamboo, sharp, seasoned hardwood spikes prepared by natives, flakes of flint rock or perhaps coral. If your matches are wet or absent, and your lighter out of fuel, or absent, then you will have to use a variation on rubbing two Boy Scouts together. You may not find enough dry wood in the wet forest. Standing dead wood is more likely to burn than fallen wood, which may be rotten. If you can find a dry log, hold it steady on the ground with your feet or knees, and with a hardwood twig force a furrow in it, about four inches long, the point of the twig on about a 45 degree angle away from your body. Keep up sharp strokes away from your body until the tinder wood which collects in the furrow ignites. (There is no guarantee that it will!) Blow on it vigorously, and add small bits of dry kindling. Another method is the old American Indian fire-bow, used by Boy Scouts. Also, the use of lenses, as of binoculars or gun sights, to concentrate sun rays on finder; or steel and flint or other hard rock, might succeed in getting a fire started.

2. Finding Water

a. Wells

Where do we get the water to fill the container? On the larger islands there is likely to be an abundance of flowing water, or even stagnant pools, in the wet season. What of the small volcanic or coral islands where there is no thick forest, and where the rain is immediately absorbed into the ground? Digging will get you to it. Naturally, the lower the ground, the nearer you are to water. Try digging a shallow well. If you are close to the ocean's edge, water can be found on the shore, a few feet down. There is some disagreement as to whether you should dig at the low-tide or the high-tide mark, but the nearer the high-tide mark, the less brackish the water will be.

b. Coconuts, Vines, Bamboo

Water can also be found in green coconuts (almost a pint per fair-sized nut). This water is refreshing, harmless and in fact healthful. Large quantities, taken over a period of time, may cause a slight looseness of the bowels. Do not bother removing the entire husk of the coconut. Cut off the top of the husk and then chip out the blossom end. This can best be done by holding the nut with the husk cut away, and striking the shell on all sides with a machete. Or poke a hole through one of the eyes.

Some large, ropy vines contain water. The vine must be notched or cut in two places, a couple of feet apart, to release tension and permit the water to flow. Cut a three-or-four foot section off the vine, and let it drain. Beware of vines with milky sap. They will be poisonous.

Some growing bamboo stems will gurgle when shaken. A notch will release the water.

A container for water can be made by cutting out a segment of green bamboo, as wide as you can find. The segments are hollow. Cut off the top of one cylindrical segment and use it for a stopper. This container can also be used for boiling or cooking. The wood will char but will probably hold the water.

B. Forest Fare

Since one would not ordinarily expect to take up housekeeping in the wild, but would hope merely to keep alive until rescued, a great variety of foodstuffs need not be sought. But it is important to know, before one starts on a mission, about a good variety of useful tropical plants and animals, because only one or two types of edible might be at hand in any one section.

1. The Coconut

If there are coconuts around (and they are another reason to try to get to the coast, where they are most abundant), you are likely to depend on them for water, meat, salad, and oil--to garnish your food and also yourself, as protection from the sun.

First, how to get them? Some may be lying around at the foot of the tree, but these are likely to be too mature, without much water, and too rich for regular food. You may have to climb a tree, if your aim with a stone or another coconut is wild, and the fruit stubborn. Pick a small tree, growing bent over. Use a climbing cloth or strap, either around the body or as a base for the feet. It should be a couple of inches longer in circumference than the girth of the tree. The weight of your body will keep it taut, and after you have lifted yourself a way, pull the strap up with the feet for another "step". Toss the nuts down to the ground--the husks will prevent breaking.

How to get the husks off? The native husking stick will serve: it is a sharpened hardwood pole, about two inches in diameter, about three feet long, fixed in the ground with sharp end up and pointing away from the body. The nut is brought down sharply on the point, and some of the husk wrenched off at each blow.

The rich meat of the mature nut can be grated with a piece of dead coral, then squeezed for the oil. Other edible parts of the plant are the fresh shoot of the germinating nut, and the celery-like heart of the tree, called "millionaire's salad".

While we are counting the blessings of the coconut, we should not forget the usefulness of the leaves as thatch material; of the large frond-branches as cross-beams for a lean-to; of the cloth-like bark covering as a source of rope or head covering,

2. Other Food Plants:

There are dozens of other plants that could supplement or take the place of the coconut. And of course, on higher ground, where the coconut palm does not grow, other foodstuffs must be found. It would be pointless here to go into a full description of each of these plants, with methods of preparation. But a mention of those plants you should be able to recognize might direct your attention to one of the numerous manuals on tropical plants now available.

Papaya: palm-like tree; fruit like cantaloupe, yellowish green. Avoid the milky sap from tree or rind. Green fruit must be cooked.

Mango: trees 30-40 feet high, broad spread. Reddish yellow fruit, bigger than baseball. Some have turpentine taste; some people are allergic to the fruit.

Cassava (tapioca, manioc): cultivated; plant shrubby, up to 7 feet high. Tuberous roots; two kinds, bitter and sweet, hard to tell apart. Bitter must be cooked. Mash roots, squeeze out juice, bake thin patties.

Breadfruit: some wild; tree 20-40 feet high. Fruit spheroid, rough and warty, 6-10 inches diameter. Yellowish green. Bake.

Yams: cultivated; like sweet potato, but can be larger. Grows on leafy vine. White to purplish flesh. Avoid spiny yam with three leaflets.

Sweet potato: does not occur wild. Shoots and greens make good greens when boiled.

Taro (elephant ears): must be cooked. Looks like oversize rhubarb. Tuberous roots.

Wild figs: ripe at certain seasons. May be several colors, several sizes. Fleshy sac with seeds inside.

Bamboo shoots are a good source of nourishment.

There are several other kinds of plants which can be used for food, but these are the best known and most easily recognized. Another point: a patch of these plants is an indication of native habitations in the vicinity, frequently.

Not all of the various edible jungle plants can be found in any one area. Troops will have to search for clearings planted with sweet potatoes or maize. Some fruits and vegetables, while not poisonous, are so bitter that eating them is impossible. Some edible fruits growing wild have poisonous seeds. In general, eat anything that looks edible; take a small quantity of food you do not know, and wait eight hours to see whether it causes trouble on reaching the intestines. Seeds and nuts and roots are more likely to be poisonous than fleshy or juicy fruits, or green vegetables. If you discard whatever has a nasty taste, and seeds and nuts, then the danger from fleshy fruits, or green vegetables, is practically nil.

C. Animal Food

All animals are edible--if you can catch them. Young monkeys are as tasty as rabbits. It is wise to cook the flesh of all animals killed, even if you are so hungry that you are willing to eat them raw. Parasitic infection of animals is common. Snakes are edible too--if you can catch them. Snake farmers in Florida make a good living canning rattlesnake meat. If in hunting you follow animal trails, beware lest you yourself fall into a native trap-pit, fitted with sharp spikes. Surplus meat can be preserved by cutting into long thin strips, soaking in salt water, and smoking it over a fire. It must be soaked and boiled before eating. Grubs and termites are considered delicacies by natives, and therefore should not be scorned as emergency foods.

D. Fish

Fish and shellfish are another important source of food. Fish can be caught with line and hook from the kit, or in shallow water, gigged with a large thorn attached to a stick. Natives use large spears, perhaps with three prongs of sharp bamboo cut out of or attached to the long handle. Night fishing with a torch or flashlight attracts the victims, which seem stupefied by the light.

1. Poisonous or Safe

Most fish are edible, except the families related to the parrot fish, the puffer fish, and the porcupine fish. Most poisonous fish do not have scales on the skin, but a leathery or spiny outside. If the one you catch looks simply like a fish with which you are acquainted, with nothing unusual about it, it is most probably safe. It is possible, however, that many of the reef and lagoon fish may be poisonous for part of the year, because of poisonous substances they eat at the time. There is a standard test for any kind of food. Eat a small bit; if it makes you sick, induce vomiting by swallowing salt water, and try something else to eat. No fresh water fish are poisonous, but they should be cooked because of parasites. Salt-water fish may be eaten raw. But in all cases, removed the insides as soon as possible. Intestine rot first.

2. Shellfish and Turtles

Small mollusks or shellfish, such as clams, oysters, and mussels, are the most easily obtained of tropical seafoods. Only those shellfish which grow in the shape of a cone are to be avoided. They bite. They are easily identified.

Shellfish can be gathered on the beach at low tide, or by digging where small air-holes are apparent in the hard sand. Since some varieties bite, or clamp their shells, it is wise to dig with a stick. Some of the larger clams, for example, can cause a dangerous wound; they may be two feet in diameter. Boil all fresh-water shellfish, because of parasites. One method would be to cover with sea-weed and have a picnic clam bake. Snails may be considered a delicacy, but certain varieties are the carriers of young flukes, the cause of schistosomiasis in man.

Turtles and their eggs are good eating. Follow the turtle trail out of the water to the place where the eggs have been deposited in the sand, and dig about two feet. The turtle has powerful jaws, which can bite even after the head is severed from the body. Consider this just another test of your commonsense and alertness.

V. SUMMARY ON TROPIC SURVIVAL

Let us go over the general principles of tropical survival. Think of them again and again, and you will realize that they amount to the same lessons you have heard again and again in military training: caution, commonsense, analysis, and patience.

1. When you have to crash-land or bail out, have equipment at hand, so you can act fast without forgetting anything in the scramble.

2. Keep your head. Do not rush madly into the jungle. Do not rush anywhere. Sit down where you are, unless it is on an ant-hill, and figure out where you are, where you want to be, what chances there are of rescue right where you are.

3. Depend on the natives, unless there is very definite reason why you dare not. Treat them as equals; make the first advances, explaining clearly what you want, in English or in sign language. Keep every promise you make.

4. If you have to leave your plane, try to get to the coast. Follow water courses to sea-level.

5. Do not worry about animals and snakes. Ten to one you will never see either.

6. Eat any plant you see monkeys eat, except for certain seeds, which they either swallow whole without digesting or spit out. Other animals and birds may eat stuff poisonous to man.

7. Salt-water fish are edible raw; fresh water fish must be cooked.

8. Beware of mosquitoes, ticks, leeches. Do not scratch sores or bites. Get under cover before dusk.

9. Beware of polluted water. Boil or purify all water.

10. Take salt tablets. Heat exhaustion may hit you suddenly. You may sweat out as much as a pint of water an hour, with its salt content.

11. Try to keep yourself clean and dry. A tough job, we know, but worth trying.

12. This will be hard to take, but try to regard a jungle trip as simply another kind of military assignment, to be taken in stride after proper preparation and adjustment. Then you are more likely to be set and less likely to lose your head and your life.

ARCTIC, DESERT & TROPIC INFORMATION CENTER

PERTINENT DATA ON AIR FORCES ACTIVITIES IN ARCTIC, DESERT, AND TROPIC AREAS

NINE SCHOOL LECTURES

APPENDIX

Prepared by

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GENERAL INTRODUCTION

Nine-Lecture Course on Arctic, Desert, and Tropics

(Headquarters, Army Air Forces
ARCTIC, DESERT, AND TROPIC INFORMATION CENTER
Office of the Assistant Chief of Air Staff, Intelligence)

The increasing success of American arms is a direct outcome of experience and improved training. The best training for combat is combat itself, but this is also the most expensive. The greater the knowledge which soldiers take with them to theatres of operation, the less costly will be their initiation.

The obvious rule, applied to any emergency, of "keep cool and have confidence" is easy advice to give, but it must be backed by something solid. This course on how to live and survive in the arctic, desert, or tropics is intended to give a background of information, based on scientific study and the experiences of Air Force flyers and crews, that will serve in both day-to-day operations and periods of emergency.

If this information is to be of any use, it must be made the basis of training. Men properly trained will do the right thing the first time, and will not have to suffer the consequences of the trial and error method. Knowledge in books, or even in the head, is of small value unless it can be used at the right time. Training and preparation begun immediately will save much trouble, and many lives, under combat conditions.

The first general point to be mastered, in order that training be of greatest benefit, is that one should get used to the idea of living in these extreme areas. In all sections where American soldiers will find themselves for the first time, there are perfectly normal people who have spent their whole lives--fairly comfortable lives, too--without any more anxiety than most of us have in making a living in our own environment. These "natives"--Eskimos, desert nomads, bushmen--grow into the knowledge of how to live where they are. We do not come by this knowledge of their environment naturally, as they do, but we can learn it. The natives are adapted by background and lore to their surroundings. We can take advantage of their knowledge, and apply it to ourselves. We can be almost as intelligent as the "ignorant" aborigines, if intelligence means ability to adjust to circumstances and environment.

Knowledge, then, makes for confidence. First we must be aware of what we have to unlearn. Let us immediately rid ourselves of fear of the unknown, the same fear an old country woman may have of tall buildings and subways and escalators. And we must also rid ourselves of false notions about these areas of the world where we may shortly find ourselves. Is it really true that the jungles abound with poisonous snakes and man-eating wild beasts; that a mirage in the desert is a sign of approaching loss of sanity; that falling asleep in the snow means eternal sleep, or that frostbite should be rubbed briskly with snow? Living and surviving, whether in one's outpost base, or after a bail-out or forced landing, depend on the proper answers to questions like these.

This nine-hour course will take up the three areas: arctic, desert, and tropic. Under each section will be treated, in about three hours, the general living conditions and necessary adaptations to the environment; maintenance and operational problems of aircraft; and behavior for survival of personnel lost or forced down. Always the key word will be adaptability--it is the flexible man, alive to changing circumstances, who turns up for another battle.

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The instructor is not expected to present these lectures exactly as they are written. They must be adapted to the time allowed, the state of training of the men, and the closeness to combat theatres. In some lectures, more material is presented than can be comfortably treated in an hour. The instructor must judge what should be condensed or omitted.

In anticipation of various training aids now in preparation, instructors can find illustrative material to accompany these lectures by referring to other publications of the Arctic, Desert, and Tropic Information Center. Several of the Center's Informational Bulletins are illustrated with drawings which can serve as the basis of blackboard or chart sketches.

Because of the recognized shortcomings of the unassisted lecture as a teaching method (F. M. 21-5, par. 72), the instructor should seek to make the material vivid by student participation. Some activity can be arranged for the classroom; other experimentation can be done after hours. In class, the instructor can review, and the class practice, the use of the compass, and the telling of direction by watch and sun; the instructor can demonstrate the purification of water with halazone tablets or iodine, and he can obtain and display the various emergency kits and their contents.

Outside of class the instructor can arrange several fruitful projects. He can assign teams of students to test some of the devices in the lectures: making dead-man moorings in soil; building fire with the fire-bow or fire-plow methods; smudging a fire with engine oil for a signal; digging in beach-side, if available, for water; making a raft with logs, using vines as binders; making snares for birds, and spears for fish; telling direction by stars; camouflaging installations.

There are some sections which are perhaps better not included in their present form: for example, the various lists of contents of emergency kits, and the lists of native foods available in tropic and arctic areas. The instructor should use his own judgment on the degree of interest his own class will find in such material.

The instructor can easily prepare sketch or outline maps for the various areas. Most useful would be the Southwest Pacific, showing the relations of the various island groups and land masses; the location of deserts; a projection of the North Pole area, to show comparative distances; and the situation of combat theatres and the stations of various Air Forces.

FORCED LANDING IN A CLEARING

Outline: A fighter plane makes a forced landing in a clearing, the pilot unharmed. He walks out in foot-deep snow, goes to sleep in the plane. Next day, after more walking, he lights a fire, but cannot thaw his shoes or dry his socks. He goes to sleep again. Next morning rescue planes appear, drop supplies; he is picked up in the afternoon. Later, at a hospital, part of his toes must be amputated.

The pilot was without emergency equipment and rations. Even so, there was little danger, because he was not far from an airfield. He had woolen underwear, woolen shirt and pink trousers, light woolen socks, leather shoes and winter flight boots, a summer flight suit and a shearling winter flying jacket. The weather was about 15 or 20 below.

After landing with engine trouble he decided to look around, and get to the top of a nearby hill. The terrain was difficult, and he could not make it. After walking three or four hours, he returned to the plane. He went to sleep in the baggage compartment of the P-36.

(Comment: The pilot should have made a camp in the timber, rather than trying to sleep in the plane. He should have kept a fire going for warmth and as an aid to searchers. He should not have kept his leather shoes on under the flying shoe while walking around in the snow. The leather shoe, being tight, is cold, and it also destroys the shearling lining of the winter boot. After his walk, he should have got his shoes and socks off, to dry them, and dried his body after the exertion. He could have replaced his leather shoes with a cloth wrapping.)

Next day he made another unsuccessful attempt to climb the hill, returning to the plane in the afternoon. He started a fire with some dead trees. He felt comfortable except for his cold feet. He removed flying boots and leather shoes, and tried to dry them, but could not. Cakes of ice were frozen in the boots, and would not melt. He could not dry the socks on his feet, either. He went to sleep again. Next day he was discovered, and planes dropped him bed-rolls and rations. In the afternoon he was picked up by a ski plane. He was tired, but only his feet hurt. His shoes had to be cut from his feet. It was estimated that his feet had been frozen for forty hours, and the pilot was suffering from mild shock. He recovered without incident, but several toes had to be amputated, despite the excellent and immediate care he received.

(Comment: The snow could have been kept out of the shoes by a wrapping of part of the parachute as a kind of legging. His inability to dry his clothing indicates an inadequate fire and shelter. A good item of equipment would have been a light ax for chopping wood.)

CRASH AMONG TREES

Outline: A large transport comes down for an instrument landing at night and crashes among trees. Both pilots are killed. A flying staff sergeant and a civilian passenger are hurt. There are enough rations and various coverings to keep them fed and warm. But after two weeks they fear they may not be found, and decide to crawl in to the field. They keep going for four days, and are finally picked up and carried in. Despite lack of proper training, they got through.

The cargo plane, flying at 8000 feet, got over the field on which it was to land for the night and circled for an instrument landing. Below 1000 feet, it lost speed fast, and stalled, was pulled back, then began to clip off trees. One big tree did not break off, and crashed the plane. The staff sergeant and the passenger, a civilian, seeing there would be trouble, lay down in the companionway, and braced themselves. Both escaped, the sergeant with a broken leg, the passenger with a broken foot. Both pilots were killed instantly.

The sergeant let himself fall about three feet from the plane to the ground, and hurt his shoulder. He heard gasoline leaking, and in fear of fire dragged himself off a couple of yards. Then he heard the passenger calling for help. He crawled back to the plane in the blackness, afraid to strike a light. After deciding there would be no fire, they crept back into the plane for the night. They did not sleep because they were afraid of freezing to death while sleeping. They called to each other every fifteen minutes.

The sergeant had had no first aid training of any sort, nor did he know beforehand of first aid kits or emergency equipment in the ship. He could find no material for splints, and had no information how to improvise any, although there was wood in the plane.

(Comment: Although without specific instructions or training, they saved their lives by lying down and bracing themselves. The sergeant was correct in trying to get away from the plane when he heard the gasoline leaking. A fire could have broken out, even after a delay. They made the old mistake, of course, in fearing freezing if they fell asleep. The lack of first aid training, in a person who was going to do much arctic flying, was, to say the least, unfortunate. And every man on the plane should have been informed of the existence and use of whatever emergency equipment was available.)

They found Army emergency rations, which kept them alive for the nineteen days that passed before they were found. They ate snow for water, scooping it off the wing through the emergency window. There was a little stove in the plane. They had a single bed-roll, which they used as a mattress; they covered themselves with canvas wing-covers and mail bags, which kept them from freezing, although the second night the temperature went down to 40 below.

(Comment: They should have avoided, if possible, camping in the plane, on account of the cold, the danger of starting a gasoline fire, and the lack of signaling opportunities.)

They figured that they were about six miles from the airfield. They could hear planes revving up and passing overhead. But new snow covered up the plane, and the right wing was broken off, so that the wreck did not look

much like a plane, even if it could be seen from above. It was up against a 60-foot spruce tree and so closely surrounded by trees that at night, when the men lit warning signals and held them out the window on hearing a plane overhead, the signals could not be seen through the trees. Also, when later they built fires outside, the smoke could not be seen above the forest.

During the second week they built a fire whenever it was clear. Dry wood was hard to find, but they used crates from the plane.

(Comment: A good fire probably would have been seen from the air. They could have used gasoline to help keep the fire going, even with poor wood. An ax would have helped.)

On the eleventh day they decided that the sergeant, the younger man, should try to crawl to the airfield. On the thirteenth day he started out, his bad leg strapped to the little toboggan sled carried by planes, and his right foot strapped to a ski. If he fell down, it would take twenty minutes to untangle the broken leg, and get up. This happened three times. A quarter of a mile out he heard a plane straight ahead, but when the plane took off it appeared from the rear, so he knew he had been thrown off by the echo. He had been out three hours in the wrong direction. Although the trip back was uphill, he made it back to the plane after dark. It was a warm day, and he was wringing wet with sweat. He undressed and got dry, at the insistence of the passenger.

(Comment: They were lucky that the plane carried rations. There certainly should have been more than one sleeping bag on the plane. They were wise to use it as insulation beneath them, since they had other covering. Their injuries and the thick forest prevented their making a definite smudge fire. Leaving the plane was probably a mistake, but the impatience resulting from almost two weeks of vain waiting, with planes all around, can be understood. The warm weather should have caused the sergeant to take off his clothing, but his exertion and his falling made getting wet inevitable. The civilian was wise in causing him to undress.)

Next day, the fourteenth, both men set out in the right direction, about 1300. They put some meager rations on the sled: 4 packages of dried noodle soup, 7 bouillon cubes, 3 inches of sausage; also, matches, hunting knife, a pistol, and an extra parka and leather jacket. By crawling, using hands, knees, and elbows, and pushing and pulling the sled, they kept going. This went on for four days.

(Comment: It might have been wise to wait until the next morning, to try to insure as few nights out in the open as possible. But their food was running low; their most abundant article of equipment seems to have been courage.)

On the fifth morning, having pulled themselves along 100 feet, they heard a shout. A Canadian Mountie came through the brush. They were saved. The policeman, with an Army lieutenant, had found the trail of the false start, traced it back to the plane, then followed the double train to where the men were. They had crawled four miles in four days. The Mountie went for help. A plane soon dropped a mailbag full of rations. A rescue party with toboggan and sled took them to a ski plane, then to the field.

(Comment: It appears likely that the ground search would have found them, if they had not moved, since on the eighteenth day it got within a quarter mile of the plane, to pick up the first trail.)

FOURTEEN DAYS ON GREENLAND

Outline: Three flyers ferrying a bomber to England run into fog and crash-land safely in Greenland. After 6 days they start toward the coast. A plane, searching, sees their signal, and drops supplies and a note to keep going. When they get to the coast the patrol boat waiting for them is ready to give up hope, and is sailing off. They set fire to their parkas, are noticed, and are picked up. They came through despite a number of almost fatal mistakes.

Two pilots and a navigator took off from Newfoundland and ran into heavy fog. Their radio went dead. After flying blind for six hours, and with half an hour's gas left, they had to seek a landing. They went down to 500 feet, over a snow-covered plateau sloping to the sea from jagged mountains. The plane landed easily, wheels up.

The pilot stepped out, sank into snow to his crotch. The other two pulled him back in. It was getting dark, and the thermometer showed 34 below zero. Sandwiches and coffee were frozen solid. They sucked and chewed the food, and smoked. They pounded each other and kicked their feet against the floor and sides of the plane to keep warm. The air-speed indicator in the cockpit showed a wind of 62 miles an hour, which could be felt right through the plane. The navigator thought of ripping the parachutes into strips and wrapping them around bodies and feet. This helped, but by midnight the temperature was 41 below. They huddled on top of each other. They got no sleep.

(Comment: The most striking fact is that they had no sleeping bags, no stove, no proper rations, no extra clothing, no special arctic clothing and only one package of paper matches, and one lighter, low in fuel. Next, they could have fought the cold better by digging into the snow, and keeping their parachutes as insulation between them and the snow. The plane cut the wind somewhat, but not the cold. A light tarpaulin would have been useful for shelter, and for lining a snow hole, for insulation.

(They might have improvised a stove, for airplane engine fuel or anti-icing fluid. A tin can or metal cylinder, of small diameter and with closed bottom, can be packed with non-inflammable insulation at the bottom, with a hole for draft just above the level of this insulation. On the desert, such a stove is packed with sand as a wick.)

They rationed their single box of iron biscuits to one apiece each 24 hours. The blizzard continued through the second day. Their feet froze solid, and they feared gangrene, but did nothing. The third night the wind died down, and the navigator took their position, just within the Arctic Circle, 15 miles from the Atlantic. They decided to inflate the rubber dinghy, drag it over the snow to the open water, and paddle 110 miles to the nearest inhabited place on their map. They would need snowshoes, and made them out of plywood box tops, and a cushion. They also collected compass, marine distress signals, and Very pistol.

(Comment: The decision was a long chance. They did not know the terrain, the dinghy might scrape apart or be blown away in transit, they had no supplies, the ocean water might be rough, and certainly would be cold.)

The wind rose again, and they could not leave. Fooling with the radio, one got it working and picked up a Canadian airport, weakly, and broke in with an SOS and their position, and got an acknowledgement just as the batteries cut out.

(Comment: This was the factor in their salvation. Clearly the radio is the most important factor in such a situation. The moment they made contact, they should have decided to stay where they were.)

There was no let-up in wind and cold. Ice covered the inside of the plane. They still had not slept, but seemed no longer tired or hungry. On the sixth morning the weather cleared and they inflated the dinghy, destroyed bombsight and papers, and started. The way was hard, and the wind started again. They went back to the plane.

Next day the temperature went up 54 degrees, and rain started; the snow was slushy. They set out and kept going til dark. That night their flying suits and boots froze like armor. They crouched beside the propped up dinghy for 17 hours of darkness.

(Comment: Their setting out at all, after the previous day's experience, and in such slush, seems incomprehensible. Their getting wet outside and inside might well have been fatal.)

When light came, they started again. They had to go off course to avoid a crevasse. Then they heard the sound of a plane. Only one of the marine signals worked, but that was enough. The plane circled and dropped small parachutes with food, clothing, sleeping bags, ropes, snowshoes, and a note of instructions. They put on dry clothes and started to eat, the equivalent of three meals. Then they got into the sleeping bags and fell asleep, the first time in nine days. They woke up, sick, an hour later. That night rain and sleet soaked and froze everything; they stood for 17 hours, holding the sleeping bags above them to keep the rain off.

The next day, because of fog and the fear of crevasses, they stayed put. They massaged their swollen feet with some of the Scotch which had been dropped to them. In the afternoon the fog lifted and they went on, following dropped instructions to rope themselves together and head to the coast, where a patrol boat would pick them up. They were weak, and discarded the sleeping bags.

That night they huddled together with arms around each other. After an hour they froze together, and they used much of their remaining strength to pry themselves apart. The ice-cap was heaving. They sang, with bleeding cracked lips, to keep their courage up. The next day was clear, but there were more crevasses as they neared the coast. In the afternoon they saw a boat in the distance, and gave everything they had to get to the coast. When there, they tried to burn their parkas, but these were too damp. Later the ship shot flares and sent a search light over the coast, but missed the men. At daylight a plane took off near the ship, but did not spot the men. Toward dark the ship began to head out to sea, til lost in the dark. As a last chance, they tore a parka into strips, and after much sparking with the lighter, got a fire going. There was a burst of flares from the ship in return. They were picked up later. The ship's doctor said they were in a condition between sanity and insanity, and would

have cracked in another night. Two months later the men still could not get themselves warm, even in a heated room, and could not sleep more than an hour or two at a time.

(Comment: The great wonder is the young men's stamina, and that they lasted as long as they did. They made the most serious mistakes: flying without equipment, staying in the cold plane, getting wet, outside and inside, leaving the plane in changeable weather. Yet they came through. Once they made radio contact, it is clear they should have stayed with the plane: the patrol plane which found them would surely have found their crashed plane a few miles away, even if they had not known how to make their plane more apparent. They evidently made no attempt to prepare oil and rags for a smudge fire, or to arrange the snow into a signal. They could have taken along rags soaked in engine oil, to which they could have set fire on the coast when their parkas failed to burn. They had the most extreme luck in not running into a filmed-over crevasse. We must give credit to their endurance and courage, but use the incident as a warning.)

LANDING ON A FROZEN LAKE

Outline: A C-87, carrying 20 military and civilian personnel from Greenland to Presque Isle, runs into icing conditions and has to land in northeastern Quebec, near Labrador. They have little food or equipment, but their radio attracts help before it dies. Next day they are seen, and supplies are dropped. Four days later more supplies are dropped, and a C-49 lands, with a live radio, to help. Equipment is dropped for better shelter. Later the passengers in need of medical attention are taken out by a bush pilot with a ski-plane. The C-49 takes off on a double wheel-track dug in the snow. Later the remaining passengers are taken out. Finally, two months after landing, the C-87 flies out, using a long run-way constructed by a small tractor flown in on a C-47, after attempts to flood and freeze a runway fail. The saving of both passengers and plane is a tribute to cooperation, resourcefulness, and improvisation of rescue methods,

Carrying a crew of five, seven civilian patients released for medical treatment, and eight military personnel under orders, a C-87 (transport version of the B-24 bomber), became lost on a night flight from Greenland to Presque Isle, Maine. Missing the Labrador radio range, the pilot began to look for a landing. A smooth landing was made on a snow-covered unidentified lake, not far from the Quebec-Labrador border. Before landing, the plane had sent an approximate position, which was picked up by various direction-finding stations.

Next day, Feb. 5, while making contact with searching planes, the radio batteries were exhausted. Next evening a plane returning from another mission but on the lookout for the lost plane, saw emergency flares, circled, and requested bearings from various D/F stations, to help fix the position. Bedrolls and food were dropped. Before this, the grounded C-87 had very little: two small cans of chicken, two cans of tuna fish, six pounds of candy, some biscuits, and some sugar.

(Comment: The effectiveness of the growing signal system in U.S. and Canada is proved by the promptness of search and discovery. A defect in preparedness is apparent in the meager supply of food carried.

Certain elements of good fortune should be observed:

1. The craft was landed without injury to personnel.
2. The radio functioned before the landing, and drift was not excessive --that is, they were not so far off course as to make rescue improbable.
3. They were found in far less time than is usual in such cases, and thus some casualties were probably prevented.)

After four days of disappointment, due to insufficient navigation information, bad weather, and the confusing sameness of the landscape, with hundreds of dotted lakes, a search plane located the C-87. Dropped kits of emergency equipment were collected in an inflated life raft used as a sled. There were medicine, blankets, heavy clothing, sleeping bags, food. Meanwhile the circling plane broadcast on its strongest frequency to assure a more definite fix. As a result there developed a regular shuttle supply system. Later that day a C-49 landed to observe and report conditions with its radio. It made a short run and stopped short, but without harm, in fifteen inches of snow. The men on the ground had marked out a space with the words "Landing Area". It was apparent that takeoffs were impossible without a cleared runway. The C-49 requested snow shovels by radio.

The C-87 party were in bad shape. The weather was cold, and shelter inadequate: a half open hut in the spruce woods, and the fuselage of the plane. They needed food and camp equipment, and suffered from frostbite, exposure, inflamed eyes from wood smoke, besides the civilians' original ailments.

Attempts were made both to clear off a runway, and to stamp down the snow. Neither process seemed likely to succeed, and besides, fresh snow wiped out the work.

The five men of the C-49 slept in their plane. They were very cold, with both clothing and sleeping bags inadequate. A substantial camp was necessary. A request for material got through before the C-49's radio batteries ran down in the cold. This was parachuted down on February 15. A hut 12' by 12', previously framed with snow walls, was roofed with wing covers, and two pyramidal tents set up, with drum stoves. A fireplace of rocks and a cooking shelter were also constructed. Much continual effort was necessary to gather wood.

It was decided to dig two ten-foot wide wheel tracks for the C-49. With the personnel in improved condition, this work went on steadily. On Feb. 22 a small passenger plane on skis landed, and three days later took out seven passengers who needed medical attention. On Feb. 26 the parallel-track runway was completed, 1257 feet long, and the C-49 made a dangerous but successful take-off. Next day the ski-plane returned with three experts entrusted with the job of getting the C-87 up, and two pumps which were intended to freeze a runway with water from the lake.

On March 6 and 8 an AT-7 made two trips and took off most of the remaining men. Finally the freezing job was abandoned because the deep snow absorbed the water and formed slush. The men remaining called for a C-47. This was fitted with special large skis and made a landing, carrying a small tractor and a great deal of gasoline. This tractor cleared a 2050 foot runway, and on April 8 the big C-87 made a take-off with only 50 feet to spare, and flew to Presque Isle.

(Comment: This story is more than an illustration of survival procedures. It is a precursor of what is likely to be a large scale program of signal and emergency rescue stations in the north. It is clear that an organized system of supply and equipment is necessary to take care of increasing operations all over the north. The flexibility of the rescue airplane has been proved repeatedly. Special types of planes may have to be designed for this work. Out of this lake incident several recommendations for navigation instruments and equipment have already resulted. Some of the conclusions of the men involved follow:

Mukluks with inner soles and several pairs of heavy wool socks are best footgear. Mukluks must be dried over fire each night with inner soles removed. Best head covering is the toque.

Kersey-lined trousers are good. Fur-lined flying trousers are good, but too heavy.

Light down-filled sleeping bags are good. Breath-frost must be removed before stowage. Bags should be kept from ground by another bag, and spruce boughs.

Chances of frostbite seem greater in the morning, when body heat is lower. A part once frozen will freeze more readily in future.

Clipping the beard, rather than shaving, seemed best.

The captain of the C-87 suggests the following equipment to be carried aboard ship:

2 rolls of safety wire.

2 sets of snowshoes and 2 sets of skis, with shoes.

A master emergency kit, consisting of sleeping bags, compasses, rations, a pot-bellied tent stove (unassembled), for the crew.

Each passenger should be issued a portable kit, to be turned in at destination. Contents: sleeping bag, rations, small first aid kit, tent for each 4 men, ax and 2 hatchets, a .22-.410 gun, with ammunition; and at least one bucket for cooking.

Because of the inadequate supplies carried by the C-87 on its first take-off, there was danger of physical breakdown among some of the men. Their condition improved after the plane was found.)

Another reminder of the use of planes in arctic emergencies appears in the story of the B-17 on the Greenland ice cap. All through the long wait, the crew were kept in the fight by another B-17, which kept coming over to drop supplies whenever the weather at all permitted. The supply plane had nothing spectacular happen to it. It functioned perfectly, and kept on the job. It dropped not only material, but also news, messages, and, at one crucial time, extremely beneficial letters from home. This plane should be remembered by those who, reading of accidents and force-downs, forget that proper caution and efficient maintenance and operation can keep craft flying.

Another incident of the ice-cap saga proves the value of experience and good equipment. A light plane piloted by an expert northern "bush pilot" with an experienced navigator tried to get to the marooned crew. It ran into bad weather and head winds. An hour from the goal, the pilot brought the ski-plane down on a stretch of smooth, snow-covered ice in a fjord. But, flying in the "milk" of mist and drifting snow, the pilot misjudged distance and crashed. Unhurt, the two men struggled across a mile of broken ice to shore. Then they struggled along the coast, fighting driving, sand-like snow. By luck they fell in with Eskimo hunters, who sheltered them, then got them by dog sled to a base. Even then it was four months before communications and weather permitted the two men to get back to the continent.

FORCED LANDING IN THE ANGLO-EGYPTIAN SUDAN

Outline: A B-25, being ferried, is asked to help look for nine planes missing for three days in desert country. Planes and crews are found on the fifth day, out of gas. All are alive, none seriously hurt despite belly landings. They have food and water, and more supplies have been brought by two transports. The incident is an example of proper procedures defeating the desert.

Nine planes, on the way to the British in North Africa (8 P-40's and a lead plane, a B-25) were last heard from west of Khartoum, in a radio message that their position was unknown and the fighters' tanks almost empty. Another B-25, being ferried from Dakar, was asked by an RAF Control Officer to keep an eye out for the lost planes, now missing three days.

The searching B-25, after seeing one crashed Hurricane on the way, spotted the lost planes some distance south of the regular ferry route. They were spread over three miles of desert flat as a tennis court. But there were eleven, instead of nine planes. The fighters were in various positions of sprawling wreckage, having landed with gear retracted. The B-25 lead plane had made a good normal landing. The other two ships were identified as Douglas transports, which, it turned out, had found the marooned flyers only two hours earlier. The circling B-25 got this radio story from the ships below: The lead plane of the flock had become lost, and when the P-40's began to run out of gas, they all landed. It was almost dark, so they had to land wheels up to prevent nose-over.

(Comment: The absence of landmarks in the desert makes expert navigation and dead reckoning essential. If these fail, getting lost is likely. The pilots should have landed while it was still light enough to make a good landing, so that they could take off and continue the search next morning. They could also have landed and pooled their gas, so that one plane could do the searching. Some men were cut and bruised during the landings, but there were first aid kits in all planes, and there would be no ill results. The presence of first-aid kits shows some preparedness. It is important also to learn to land in desert dusk, if necessary.)

There were sufficient supplies. The transports had brought enough, the grounded pilots had shot a gazelle the day before, and an Arab passing on one of the nearby caravan routes the night before had given some water from a goat skin. Before that the men had recognized the danger of their position, and had rationed their supplies. The Arab rode on his mule to the nearest RAF officer, 30 miles away, to tell where the planes were.

(Comment: The rationing shows a proper respect for the desert, and an awareness of emergency, even though the men had reason to believe they were no great distance from rescue. The cooperation of the Arab is further proof that local inhabitants, if treated properly, can give invaluable aid.)

The circling B-25 was asked to report to Khartoum the exact position of the grounded planes, so that mechanics and parts could be sent.

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On the way across Africa prior to finding the planes, the B-25 spotted a crashed Hurricane, its nose deep in the sand, its tail straight up. The cockpit was empty. Dragging over the crash at as low a speed as possible, the pilot could see no messages in the sand, no arrows formed by pieces of parachute or other objects from the plane to indicate the direction the pilot had taken on foot. The B-25 radioed the nearest British station, and was actually greeted by the Hurricane's pilot. He had "walked for three bloody days" before a caravan found him and took him to El Genina, an air station.

(Comment: Although information for judgment is meager, it seems fair to say that if the pilot had enough supplies and stamina to last at least three days of traveling in the desert, he might have been wiser to remain with the plane, holed up in its shadow during the day, awaiting rescue. The crash was on a well-traveled ferry route, as its observation by the B-25 proves. The crashed pilot took an awful chance in breaking across country. He was lucky to be in caravan country. At very least, he should have indicated by scarring the sand, or otherwise, the direction of his travel. He apparently had not made his way to the crash after bailing out.)

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Another incident is related by the B-25 pilot. A ferry pilot had crashed en route north to Cairo, 200 miles north of Khartoum, 40 miles west of the Nile. Other pilots found the plane, with a penciled note on the wing: "Walking in easterly direction towards Nile. Water container crushed in cockpit. Leg injured. Breckinridge." A few miles east his body was found. Buzzards had got to him first.

(Comment: The lost pilot probably did right in trying to make it to water, and human habitation, since his own water was gone. His wound must have been fatal interference. It seems likely that he started walking during the day. Under the conditions, he should have waited until the cool of evening before undertaking the exertion.)

ELEVEN MEN DIED--WHY?

Outline: Three British Blenheims leave their base, are lost, land, send out one plane to search, unsuccessfully. They do not ration water; when it gives out, they drink alcohol from compasses. All the men but one are dead by the eighth day, when they are found. Terrain and weather are bad, and the search does not begin until the fourth day. Failure of discipline and proper procedure was disastrous.

The three British Blenheim light bombers, each with a crew of four, carried out a patrol successfully, and returned to their base at the Kufra Oasis in the Libyan desert. But instead of landing, the planes for some reason flew away again.

(Comment: The Flight Commander disobeyed standing orders in taking off on a completely unauthorized flight instead of landing. This bad leadership offers a key to the entire disaster.)

A half hour from the field, one plane made a forced landing. The other two followed. Discussion showed they were lost. One pilot took off to search for the base, came back in half an hour, and took off again in

the afternoon, in a different direction, again unsuccessfully. During this time all three aircraft were transmitting by radio, but got no answer.

(Comment: It is apparent that faulty navigation got the planes into this fix, and helped keep them there. It turned out that none of the three navigators had kept a proper log.)

During the second day another pilot took off in a third direction, and on the third day another pilot went off west, the only direction not searched. This plane did not return.

According to the only survivor of the twelve, they had been so confident of being picked up soon that they did not ration their water. They had used twenty gallons by the second day, when it occurred to them to start rationing. The water gave out on the third morning. In the afternoon they broke open the compasses and drank the alcohol. They also used the fire-extinguishers to keep themselves cool. They fell into terrible torture, breaking out into blisters and sores.

(Comment: Almost unnecessary. It is hard to believe such a proof of bad training, weak discipline, and downright ignorance.)

On the fourth morning the first man died. During the following four days, all the other men died except the lone survivor. One man shot himself. On the eighth day the two remaining missing craft were located.

The search had been hampered, first, by lack of accurate information. Failure of navigators to keep a log made it hard for them to know in which direction help lay. The wireless transmission was weak, and the direction-finding procedure of the operators-gunners was faulty. They were evidently not aware of D/F procedure at Kufra.

(Comment: Bad preparation is obvious. The men were badly trained in general, and they had not mastered procedures at their own base.)

Bad terrain was another hindrance to search. Sandstorms obscured the ground. Searching aircraft did not start operating until the fourth day, and then were naphazard, not following a properly coordinated plan. The first proper navigationally-planned search found the planes within five hours.

(Comment: A tragedy of errors. Even with faulty navigation, and bad wireless technique, the men could easily have survived. They had at least two gallons of water per man, and were only half an hour from their base. If rationing had been put into effect immediately, they could easily have survived until found. They failed to lay out any strips or make smudge fires, which might have guided searching aircraft. An ignorant and inept flight commander has to be given the major blame for the event. But behind this, there was an obvious lack of a training program for all the men.)

(Material from RAF magazine, Tee Emm)

BAIL-OUT OFF AUSTRALIA

Outline: A pilot's P-40 is shot up, and he bails out over water. Swimming in he lets go of kit and clothing. He finds the island barren. Burned and hungry, he is found by natives, whom he fears, but who feed him and take him to a missionary on the Australian mainland. The pilot realizes that his behavior increased his difficulty, and that he should have managed more easily.

After shooting down two Zeros, in a mixup of four P-40's and twelve Zeros and ten Jap bombers, the lieutenant had to bail out as his battered ship went out of gas. It was about 1700. He was carrying only his jungle pack.

He slipped out of his chute about fifteen feet before he hit the water. But his Mae West failed to inflate. He got rid of it, and then felt he had to lighten his load. He discarded his shirt, shoes, and socks. The jungle kit quickly became waterlogged and he had to discard that, salvaging only the machete. This too impeded his swimming, and he had to let it go. He made the three mile swim to shore, landed exhausted, and fainted.

(Comment: The failure of the life-preserver is probably to be blamed on the pilot himself. Equipment, including CO_2 bottles, should be checked before every mission. He followed correct procedure in getting out of the parachute before it hit water, thus avoiding entanglement. After this, some practical training would have helped him greatly. He should not have discarded clothing. Every soldier should know how to use shirt and trousers to catch air bubbles, which act as life preservers. With such knowledge he could have kept his kit afloat, and saved himself much trouble later.)

When he came to, things looked bad. He was on a sandy, small barren island, with nothing to sustain life. He fell asleep, and awoke next day in a burning sun. He found some shrub roots which were edible, and he nibbled some leaves. He dug a hole several hundred feet from shore, and drinkable water seeped up into it. He estimated the temperature to be about 125°, and there was no shade. He began to burn painfully, and developed some symptoms of sunstroke. Late that afternoon, he lost consciousness.

(Comment: His way of obtaining food and water was correct, so far as it went. He could also have avoided the effects of the sun, as he found later.)

He was awakened by the presence of three natives, one of whom held a spear. This one asked, "You Jap?" They did not seem to know what "American" was, but seeing a religious medallion around his neck they asked, "Jesus?" and were satisfied by the pilot's assurance. After a powwow, they carried him away from the beach, dug a hole in the sand, and covered him with leaves and branches. Then they brought him turtle eggs to suck, and they cooked

fish which they speared in the surf. They made fire with a wood-spindle. In his upset state, the lieutenant had feverish visions of a cannibal feast. "He could see the waiting pot."

(Comment: The natives of that section were aware of the war. Observe the effectiveness of their survival procedures, which a little training and calm would have made available to the pilot himself. He need not have been burned, nor did he have to fear starvation. Also, their knowledge and sympathy with Christianity should have dispelled all fears of cannibalism. Even apart from this, if the pilot had learned something in the characteristics of natives of the areas he would fly over, he would have known that Australian natives are not cannibals by custom.)

In the morning the natives pointed to the mainland, and said "Missionary". With blistering bare feet he walked with them to a dugout canoe at the end of the island. After waiting for the tide, late in the afternoon they set out. On reaching shore they started walking again, the pilot tortured by sunburn.

The next day one of the natives ripped up his loin cloth and with this tied some green bark into moccasins for the flyer. They ate more turtle eggs and raw fish. The pilot was still fearful, and armed himself with a jagged piece of coral. The spearman took it away from him, then the three natives broke into a hymn, as if to reassure him.

(Comment: His rapidly deteriorating physical condition prevented him from thinking straight. Even if he could not trust the natives, the worst thing he could do was to antagonize them, since he was completely in their power.)

The pilot gave out completely after 45 miles of walking. He was carried five miles to the mission station. He was put to bed with jaundice, fever, sunburn, and shock. The natives were rewarded with tobacco and cloth, and gained much prestige for saving him. They had learned about the war and white men through their mission training, and they hated the Japs.

After a week and a half, the lieutenant was transferred by mission boat 350 miles up the coast to another station, where his condition grew worse. The missionary radioed to Darwin, and a plane flew out and picked him up. The pilot now declares that if he had known then what he knows today, much of his suffering could have been avoided, and he might have been able to survive for months on the island.

(Comment: Certain facts stand out. Know the kind of natives you are likely to meet. Try to keep as much equipment with you as possible. Know the simple details of getting water and food on the seashore, and how to protect yourself from the sun. Above all, do not let your imagination run away.)

BAIL-OUT OVER BUNA

Outline: Wounded and tossed out of his exploding plane, a pilot lands safely near a clearing. He attracts natives, gains their confidence, and they help him, first to the wreckage of his plane, then to a mission. He decides to push on across the Owen Stanley Range. He picks up one of his gunners on the way, and finally, after great pain and trouble, is carried all the way to Port Moresby.

During a raid from Port Moresby to New Britain, five B-25's were intercepted by 20 Zeros. One pilot felt his bomber shiver, and a shell fragment ripped into his left foot. His plane went out of control, and he ordered the crew to jump. Two gunners got out, but pilot and co-pilot were trapped. Then an explosion, and the pilot found himself clear of the ship at about 300 feet. He remembered to pull the chute ring, and he floated down.

In the distance he saw the wreckage of the plane, and below him a stream and a native clearing-garden. He landed in a young tree and slid down, wrenching his back. His right knee had been gashed somehow in the explosion which knocked him out of the plane.

Machetes lying around told him natives were near. He waited, and checked his jungle kit and himself. All in fair shape, considering. He began to shout. First children came out of the bush. Then the adults. He held out his insignia, his wings and captain's bars. They were accepted, and a leader came forward, who knew some English. The pilot used some Motuan, some English. They understood. They took him first to the plane, where he found the bodies of the bombardier and engineer, killed by the hit in the air. The pilot gave instructions for the burial. Before they went on, he ground his sulfanilamide tablets into a powder and dusted it into his wounds, and used gauze bandages from his kit.

(Comment: The captain's actions were a model of proper survival procedure. He got his bearings while descending, did not lose his head, waited for the natives to come to him, then made their friendship. His knowledge of Motuan indicates preliminary preparation. His use of his kit, including the sulfa drug, shows further ability in self-care.)

Because his knee was bad, the natives carried him to a nearby mission. The people there were afraid of Jap patrols, and he knew he had to hide or leave. The missionaries told him one of his gunners had passed through, to join an Englishman who knew the country and the language, and then to head for the mountains and Port Moresby on the other side.

In a litter carried and guided by eight natives, he started in pursuit. The caravan grew as other natives joined the procession. That night they caught up with the Englishman and the sergeant gunner. The natives were paid off by the Englishman with tobacco.

(Comment: The pilot gave himself completely into the hands of the natives, who evidently were used to such arrangements. Their expectation of reward was not disappointed, fortunately for future castaways.)

Then the terrible three week trek through swamp and over the rugged mountains, ninety miles, started. A relay system sprang up, from village to village, with a new set of bearers each day. The party detoured around Kokoda, where Japs were reported. They averaged about 5 miles a day. The natives fed the helpless pilot. He did not like the food--stewed pumpkins, bananas, birds, coconuts--but it kept him alive. He took water from mountain streams and purified it with iodine til he had to save the drug for his wounds. His right knee had become infected. Meanwhile the natives went on in their own way, cleverly living off the land, taking their time, singing, laughing, enjoying themselves. In his pain and illness he almost lost his temper with them, and felt like doing some violence, but he held on. He knew he could not drive them, or show anger with them.

From the moment he hit the ground, he kept taking his anti-malaria tablets, because he knew his chances of escaping infection were small. The symptoms of the disease lay dormant through his trip, and thus he avoided added suffering, which under the conditions might have been fatal. The malaria hit him after he reached Port Moresby.

Finally the ordeal came to an end, after the captain lost 60 pounds. He was hospitalized in Australia for three months, then was returned to the States.

(Comment: It is obvious that without native help he would have lasted a short time. Even in his pain he realized this, and controlled himself and let them run things.)

A BAIL-OUT OVER NEW GUINEA

Outline: After a bombing mission over Lae, one of five B-25's is hit by a cannon shell from a Zero. The pilot orders Abandon Ship, then bails out himself. He finds natives, makes friends, is helped to a white settlement, and eventually makes his way out to Australia. An illustration of calm, proper survival procedures.

After the Lae bombing, and a fight with Zeros, in which one B-25 was forced to crash-land on the water, the flight started toward the Owen Stanley mountains, back to Port Moresby. A lone Zero attacked, sending a shell into the cockpit of one plane, and killing the co-pilot and the engineer. A shell fragment hit the arm of the pilot. Another shell silenced the left engine.

The pilot, a captain, ordered the crew to bail out. Then, after trying to keep the plane going, he left the plane at 4000 feet. As he floated down, he kept his head. He looked for signs of human life. In

one direction he saw a clump of palm trees and a clearing. He decided to head in that direction. He kept his eyes fixed on that point, and as soon as he hit ground he opened the jungle kit in his parachute pack, got out the compass and took a bearing toward where he had last seen the palm trees.

(Comment: Correct decisions all the way. With Japs around, there was no point in crash-landing. The pilot remained cool, despite deaths of crewmates, and his own wound. His alertness even while floating down probably saved his life, because he thus got to natives. They alone could get him to safety.)

He took what he wanted from the jungle kit, sticking the big knife in his belt, and matches, halazone tablets, quinine, water bag, mosquito headnet, iodine, chocolate, fishing tackle, and compass into his pockets. Then he started through the jungle to the clearing. It was hard going; water came up to his hips, and the brush was thick and brambly. With his machete he made some progress, going quietly and slowly.

He found a foot-path in half an hour, and in another half hour, he came to a clearing. Some natives stood about. The pilot raised his good arm and shouted "Hello!" to them. They answered, but seemed fearful and kept backing away.

(Comment: He was somewhat overanxious. He should have given them time to adjust to his presence, and to approach him.)

He kept going toward them, and finally shook hands with one; then they all wanted to shake hands with him. More came. One could speak a few words of English.

The pilot found he was a few miles from Buna. He was told it was too late to get to Buna that day. After putting iodine on his arm and tying it with a handkerchief, he was led to the native village nearby. There, a woman heated water to wash his wound, and he was cleaned up. The natives made fire with a wood drill and sparks from stones. They gave him oranges, coconuts, cooked yams, and taro. He gave them chocolate bars in return, then ate a bit, and went peacefully to sleep on the verandah of one of the huts.

The next day the natives accompanied him to Gona mission, where he sent a native runner to Buna, with a message to be radioed to Port Moresby. He remained at the mission until a boat arrived and took him down the coast to Milne Bay. There his arm was properly treated, and he went off to Australia.

On his way down the coast in the mission boat, he picked up the bombardier of his plane, who had been brought in by natives to one of the missionary way-stations. The man had done just about everything wrong, and for four days had had a bad time. He had been careless about his equipment, having lost his compass. Then he got lost himself. He did not like the rations in his jungle kit, and threw them away! He knew nothing of how to take care of himself, and groped around aimlessly, til

he was weak and ill. Mosquitoes were a torture. He spent the nights in trees, and the days wandering feverishly. He was afraid of the natives; when the blacks who finally rescued him approached, he was in terror, and only his weariness permitted them to take him in charge, without resistance.

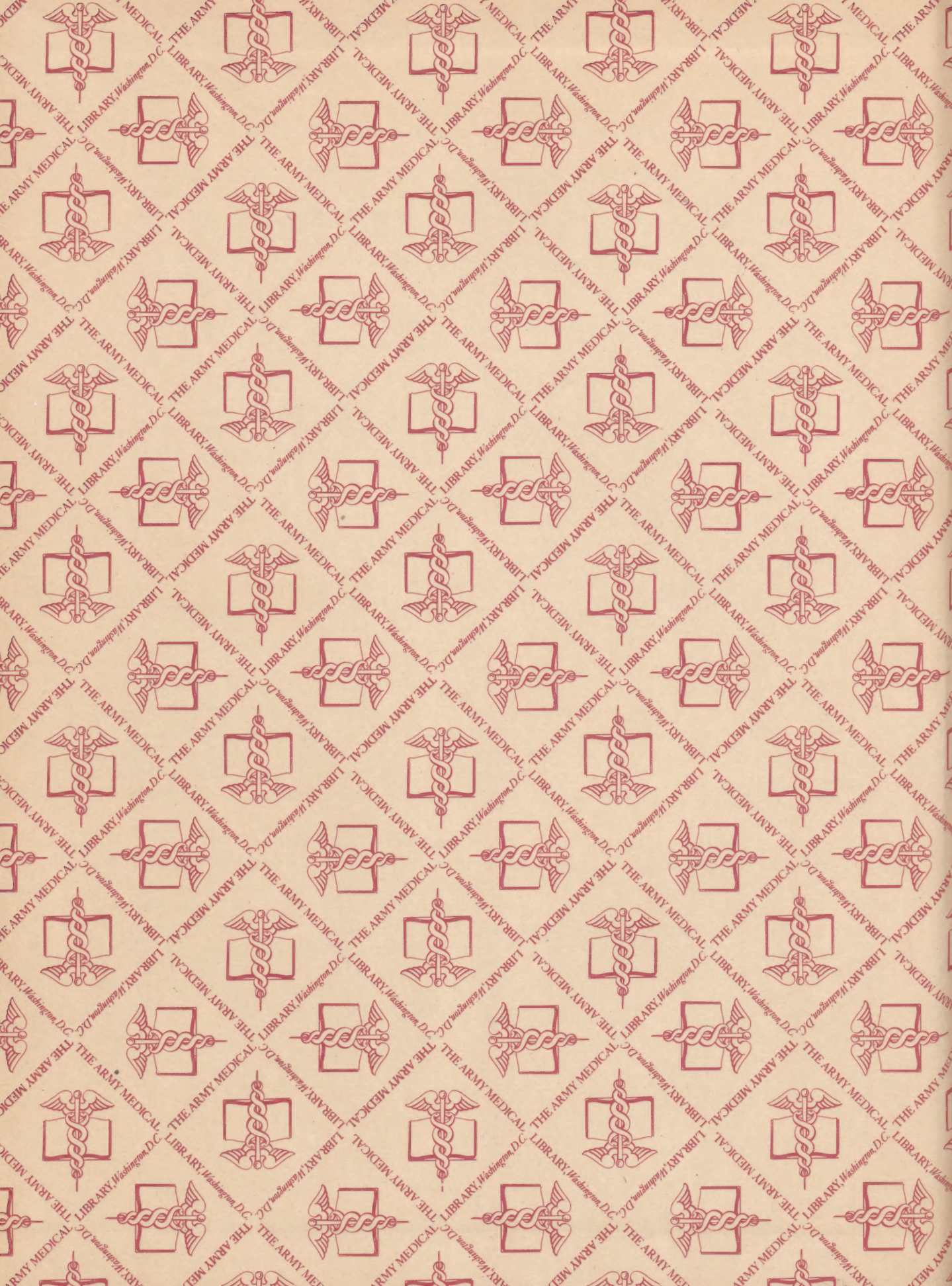
(Comment: The contrast between the pilot's actions and those of the bombardier are obvious. The pilot started planning and conserving material and energy from the beginning. The bombardier, by panic, weakened himself in a short time. Both stories illustrate the importance of native aid, and the need to keep local populations friendly.)

An expression by the pilot, afterward returned to duty in America, will point up some of the lessons: "The key to rescue in the New Guinea jungle, and in my opinion, in any jungle, is the native. You've got to have a guide to walk your way out all in one piece. To travel alone is difficult if not impossible. The natives know their jungle, know how to find and travel its paths, how to use canoes and improvised rafts on the streams. They know what foods can or cannot be safely eaten.

"During my stay with the natives, I noticed they were eager to help our men when in trouble and for very little compensation. Any part of your jungle kit will be considered full payment for whatever a native does for you. The jungle kit knife seemed to be the thing they cherished most in my case. It would more than have repaid them for anything I might have asked them to do. They prized the silk of my 'chute, too. The surest way of winning natives over is to look friendly and to be friendly and to give them something.

"I can't emphasize too strongly the necessity for learning all you can about the area in which you operate. Get to know all you can about the natives, especially their habits. Try to learn a few words of their language, at least the native words for food, water, guide, etc. You can memorize them easily and they may help to save your life some day. The same holds for prior knowledge of edible plants and animals in a given area.

"From observation and experience, I think most men forced down in northeast New Guinea or in any malarious jungle, are likely to get malaria. Take your quinine or atabrine regularly--it's a must. Sulfa powder is a life-saver, too. You'll keep your machete on your person all the time if you're smart; little as I had to travel on my own, I found it indispensable in the first phase of my rescue. What I want particularly to emphasize is the absolute necessity for preparing yourself to meet an emergency, to know something about the area in which you will operate, to prepare for a forced landing or bailout by carrying the right equipment, and checking in advance to see that it's all there and in the right condition. And last--stay cool; keep your head; use it!"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